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WILLIAM H. PICKERING'S OBSERVATIONS OF THE FORMATIONS OF THE MOON.*

Among the few serious observers of the formations of the Moon of the present time, William H. Pickering should be placed in the first rank and as the number of expert judges of such selenographic researches is only very small I will here enter more closely into the observations of that gentleman.

They are of the greatest importance for this reason that Professor Pickering could make use of a powerful instrument under peculiarly favorable atmospheric conditions and could concentrate his observations systematically upon certain objects. On the other hand, however, he was not as familiar with earlier works as would have been desirable; then, also, he arrives at some results, which, in my estimation should not be accepted without examination.

His place of observation was the station established by the Harvard Observatory near Arequipa in Peru, in 16° 22′.5 south latitude, 4^h 46^m 12^s west longitude from Greenwich, 2456^m in height. The instrument used was the 13-inch Boyden refractor, whose objective for visual observations was reduced to 314^{mm} and which was provided with a magnifying power as high as 714 times. The station at Arequipa has such extraordinary atmospheric conditions that Professor Pickering maintains that probably the Moon has never been so accurately seen, even with the largest telescopes, as by him at that station. After certain tests he arrives at the result that there in his instrument the smallest, still directly perceptible object on the Moon's surface measures, perhaps, 600 English feet or 200^m in diameter, and that the Moon appeared in the telescope as it would to the naked eye 1,000 English miles away.

I shall briefly consider the regions of the Moon as observed by Professor Pickering in the order in which he presents them; more fully, only those which I myself have observed for a longer time.

The Inner Surface of the Walled Plain. Plato:—Pickering, beginning Sept. 5, 1892, determined by micrometer measurements

* Translated from *Sirius*, Dr. Kline, Editor.

the positions of 11 of the most easily visible small craters on this surface, connecting with them later a large number of other very small craters, in all 71. He gives two schematic drawings of the interior of Plato which are here reproduced on Plate XII.*

The little craters on the lower drawing are designated by very small circles, and those whose position was determined micrometrically, are at the same time marked with a cross.

The small circles which include only a horizontal line, designate the position of craters which were registered by drawings on different nights. Those with a vertical line designate such as were entered by but one drawing.

Simple circles without any interior markings refer to little craters which were not seen in Arequipa, but were entered according to the drawings of other observers. The approximately correct recording of the latter gave Professor Pickering much trouble and he arrives at the conviction that, clearly, great changes in the visibility of some of these little craters must have taken place. The little crater No. 61, particularly, presented the greatest difficulties; it has been set down by Stanley Williams and the committee of the British Association, but Pickering was absolutely unable to find it. In my opinion, however, one is not to conclude that this crater which is designated by the above mentioned British observers as large and conspicuous, has disappeared; it has only been inaccurately drawn and is identical with Pickering's No. 62. When the atmosphere is exceptionally good, exceedingly faint objects sometimes become visible on the Moon which are not seen again for years. In my opinion their sudden visibility is not to be attributed to actual changes but merely to optical phenomena.

Of these small craters only five are large enough to have their diameters estimated by comparison with the thickness of the micrometer thread of the telescope.

It was found for craters:

	Apparent Diameter.	True Diameter.
	″	m
No. 33	1.2	2200
" 51	0.7	1300
" 41	0.7	1300
" 45	0.5	900
" 71	0.5	900

The remaining smallest craters cannot have diameters of over 0″.3 and not under 0″.2, or 550 to 380m, therefore they must be

* See Harvard Observatory *Publications*.

still larger than the crater of Vesuvius. The latter would no longer be recognizable from the Moon with our best instruments as a round depression filled with shadow. On the night of Aug. 12, 1892 the opportunity was offered of taking the measurements of the heights of some of the smaller crater cones. On that occasion at $11^h\ 4^m$ Greenwich mean time, a narrow strip of sunlight appeared on the plain of Plato extending from crater 41 almost to the eastern edge of the plain, 11^m later it had reached the edge. Later on, more streaks of light appeared and shortly before 13^h the shadow of the peaks appeared, upon the inner surface. The extreme extent of the shadow of the little crater 45 was measured, and the most probable value for the height of the wall of the crater was hence found to be 45 metres. The result for the height of the little crater No. 33 was 51^m. On Aug. 31 the trial was made to determine the inner depth of some of the small craters; the result for No. 33 was 200^m, for No. 41 and 51, 150 metres.

The most easily visible object is the crater No. 33, after that No. 51, but the latter is occasionally surpassed by No. 41. Pickering makes further communication of apparent variations of visibility of several other small craters, and gives as his conviction that this region of the Moon is at present still in a condition of volcanic activity, and more active than any other equally large surface on the Earth.

But there is no intimation of lava to be found there the white streaks, however, apparently point to something which is analogous to snow or clouds.

"There must," he says, "occur a certain uprising of gases there of aqueous vapor or carbonic acid, the former of which probably contributes to the formation of the white spots. The result of my observations prove that these gases are present there in very small quantities, according to which the horizontal refraction of the Moon's atmosphere is less than $0''.4$."

The light streaks in the upper drawing of Plate XII were entered by Professor Pickering according to a drawing of July 18, 1891, and from sketches of July 15 of that year, and of Aug. 31, 1892. He believes that since then their form has noticeably changed, and they have grown narrower, and appear likewise to be spread out over a smaller surface. To me there seems no sufficient proof of this alteration. The inner surface of Plato is noticeably more arched than the Moon's normal surface of which one can convince oneself at sunrise. This interior is subject to variations of brightness. When the sunlight first strikes it

the surface is naturally darker, but under the influence of sunlight the matter which covers the western portion of this surface, darkens immediately and very soon grows darker than the faintly lighted, pale eastern portion. But when the Sun rises higher this too grows dark. After noon the eastern portion is more brightly lighted, and therefore appears brighter until towards sunset, when the matter which covers the western portion grows pale the eastern portion also darkens.

Concerning the color, the western end of the inner plane of Plato is of a bluer color during the first half of the time, during the last half the eastern end. Between these appears a yellowish tint as if proceeding from very delicate vapors, and this matter, whatever its nature may be, has an important effect on the relative brightness of the separate parts of the surface. Compared with the Mare Frigoris at the same distance from the terminator the brightest part of the inner surface of Plato is somewhat brighter one day after sunrise and 1.5 to 2 days later somewhat darker. It increases in darkness until just before sunset, but does not return to its original brightness up to this time.

Professor Pickering concludes that the appearances on the plain of Plato go to show that moisture and carbonic acid exist there, if only in very small quantities, and that volcanic activity is at least as marked there as upon the Earth.

Linné: Professor Pickering quotes the earlier observations of this crater and concludes correctly that no one has seen it as a crater before Lohrmann and Mädler. The latter gave it a diameter of 10km and 300m in depth. Linné was always only a diffuse bright spot under a moderately high illumination. Schmidt saw it as a crater in 1843 only, in 1866 he could recognize the crater form no longer and announced the disappearance of Linne.

Pickering observed this object at Cambridge with a 15-inch refractor, on October 2, 1897 and Nov. 30 when the Sun had risen 7 to 5 hours above it. He found a small deep crater surrounded by a wall whose exterior height, measured by its shadow, could not amount to over 40m. This crater lay on the northeastern edge of a whitish ring of 16″ diameter which apparently formed the remains of a former crater which had seemingly sunken while the Mare was in a semi-fluid or plastic condition. This crater is visible during the entire lunation. Its western wall is higher and better defined than the eastern and throws a small shadow shortly after sunrise. One often finds small craters on the walls of larger ones, and Pickering believes that the original

Linné had this position also before its destruction. "Since" he says, "a large flat crater of 4″ to 5″ in diameter, was seen by at least ten astronomers thirty years ago in this place, and is no longer recognized even with a 15-inch refractor, there is ground for the assumption that a change has taken place during this time." I cannot share this view. That Linné had another form before 1866, namely, a larger one, and that it was a clearly visible crater on the terminator, even with small instruments, is certain, but I do not believe in a change after 1867. The observers, about 1867 had no experience in the perception of the finer details of the Moon, and turned their attention to Linné only because Schmidt had announced its disappearance.

To show how slight the knowledge of by far the greater number of observers was at that time, is proved by the fact that a man like Birt could not even correctly identify the crater Linné on Schröter's chart. He took for it the spot *g* of Schröter and I was obliged to repudiate this assumption as entirely erroneous.

What I myself observed in Linne in the years 1883 and 1884 I published in Sirius year 1884, p. 242. These observations are confirmed to the smallest details by those of Pickering in the year 1897, so that there has been no further change in Linne since 1883 at least, in fact not even since 1867; for what Huggins saw at that time is nothing more than the former larger sunken crater indicated by the ruins of the old surrounding wall. Pickering determines the diameter of the present Linne crater at 0″.8 or 1.3km. The diameter of the white spot in the place of the old Linne, amounted in 1866-1868 to perhaps 6″ to 8″, on the other hand Professor Pickering found this diameter to be 3″.91 in 1897, but recognized by observations in 1898 that it varies with the place of the Sun and is smallest 24^h after full Moon, which about answers to the position of the Sun at noon for Linne. Pickering gives his opinion that the outlines of this spot are more distinct towards the end of the lunar day than in the beginning of the same and the variations of its size are fully analogous to those which the polar spots on Mars show "and probably from the same cause." I must confess that if the variation of the white Mars spots did not show more distinctly and more surely in connection with the place of the Sun than those on the extension of the light spot around Linne then the whole meteorology of Mars would strike me as very illusory.

Schröter's Valley: With this name Pickering designates the great Rill of Herodotus which Schröter discovered and which is most easily seen of all lunar Rills. Pickering also gives a photo-

graph and a sketch of the same, which, however, are both deficient. Pickering was at first so perplexed by the bright light which surrounds the upper part of the Rill and the region there northerly from Aristarchus when the Sun is high, that he thought of comparing it with the exhalations of steam of an active volcano on the Earth. He therefore determined to make a series of sketches of these light spots in order to decide whether their forms varied from time to time, or whether they remained invariable like the color of the ground. These drawings appeared in the years 1891, '92, '97 and '98.

To quote the result briefly, I will point out prominently that Pickering expresses the opinion that the bright streaks and spots which become visible when the Sun is rather high in the region easterly, beside the end of the Rill near Herodotus, are steam-like exhalations, clouds of water vapor or ice crystals which were sent out by active volcanoes upon that plain. That this volcanic activity does not begin until one or two days after sunrise at this place, then increases to a maximum and generally ends a few days before sunset. Besides these, other smaller occasional changes are supposed to occur in which no law can be recognized. The principal little craters in question here on the plane are those three which are drawn in Schmidt's Chart of the Moon, on the surface just northeast near Herodotus, of which the two southern ones stand near each other obliquely. Besides these, Professor Pickering has discovered five other smaller craters in the neighborhood, but has never seen all seven at the same time. It is the unequal visibility of these and the variable form of the bright streaks which arise in their surroudings according to the place of the Sun, which have led Professor Pickering to his conclusion of volcanic action there. Meanwhile, the regularity with which the bright streaks show themselves, returning in every lunation according to the position of the Sun, seems to me to support the view that we are here concerned only with reflections of light from an unchanging surface. The apparent contours of such bright spots can vary individually very much even in very slight differences of the Sun's height, or of the libration of the Moon, while the general outlines return with every lunation. That is exactly the case with the forms above. I observed these very much earlier than Professor Pickering, even before 1881. But it is a note-worthy fact that those objects which stirred me to continuous observation of these regions, and which are conspicuous to every one who observes them during a lunation receive no mention by Pickering.

First of all is the intensely green color of the whole surface, which is surrounded by the great Rill, a coloring which is recognized, immediately, even by an unpractised eye, and has not its equal in intensity on the whole Moon. Were one to assume Pickering's view of a certain vegetable growth on the Moon, one would seek it first of all in the region of the great Herodotus Rill. Gruithuisen was the first discoverer of the color; he wrote about it on Nov. 8, 1824 in his journal, that he saw, "in the east and northeast of Aristarchus a mingling of all kinds of colors in small spots, which give an indistinct impression of plantations. That with us, vineyards, meadows, summer and winter grainfields and woodlands all mingled would have this appearance were one to view them from the Moon." Another phenomenon still appears at the mouth of the Herodotus Rill and towards Aristarchus on the plateau there, namely a violet glimmer, which begins to become visible immediately after sunrise and spreads itself out farther and farther with the rising Sun.

On the 6th of August, 1881, as the wall of Herodotus had just emerged from the lunar night, the whole region between Aristarchus and Herodotus and the southern part of the great Rill appeared to me in a strong violet light, as if covered with fog. It did not lie around the brightest mountain portions, for the eastern slope of Aristarchus which shines so brightly in the interior, showed no vestige of it, nor was there the slightest trace of it shown there where the shadow of the western wall in the interior of Aristarchus contrasts with the bright eastern slope. In order to be perfectly sure I examined all the other bright spots especially the most brilliantly lighted, but did not find even a single trace of violet light. I was observing with a 6-inch Reinfeld refractor, then used a 5-inch Plöss dialyte, which showed exactly the same thing. The coloring showed sharp outlines, nor did the violet light appear on the brightest part of Aristarchus, but was spread out over a relatively dark surface. On the 7th of August the violet coloring was spread out still farther; it now extended according to my drawing to the south between Aristarchus and Herodotus, likewise toward the west, and extended towards the east beyond the great Rill. The course of the latter in the violet light was recognizable. If Aristarchus was placed out of the field the intensity of the violet color was not altered in the least. This violet coloring appears at times of a pigment-like thickness and its expansion changes which I propose in future to discuss more at length. Here I will only call attention to the fact that Professor Pickering makes no mention of this highly striking green and violet light.

Riccioli: In this great walled plane are shown variations of color, according to Professor Pickering, which pass through their cycle in 24^h, are sometimes even very noticeable in less than 5^h, and which are ascribed by the observer to vegetation. I have not followed up these colorings and can therefore add nothing about them from my own knowledge, but I should like to call to mind that Riccioli appears strongly foreshortened from east to west on account of its great proximity to the edge of the Moon, and that apparent variations of light can easily occur in its interior, on account of this oblique view.

Messier and Messier A: Pickering's attention was drawn to this double crater through a notice in Neison's book, "The Moon." His observations began in 1891, and were continued in 1897 and 1898. They led him to the result "that no indication exists which proves a secular variation of this formation, but that periodical variations occur there from some unknown cause and occasion a series of the most remarkable changes in the appearance of this object."

Professor Pickering gives a drawing of the appearance of Messier and its adjoining crater A, lying to the right in the telescope, as both appeared at Arequipa with a 13-inch refractor, with an enlargement of 795, on May 4, 1892, $12^h\ 50^m$ Greenwich mean time. This drawing is here reproduced, in Fig. 1. It shows, according to Professor Pickering more detail than others drawn with the 15-inch refractor at Cambridge, on account of the clearer air at Arequipa. But the experienced observer of the Moon cannot consider it as very successful, nor even as very rich in detail. It is to be regretted, in general, that Professor Pickering has no sort of knowledge of earlier observations of Messier. He knows neither that Gruithuisen saw all which he now reports as new, as much as 70 years ago, and much else besides,* nor is he familiar with the numerous observations of the years of 1842-1882, which Julius Schmidt published in his communication to me† and finally is also unacquainted with the series of observations by me‡ from 1877 to 1883, and the numerous communications about Messier in the various volumes of "Sirius."

The material published in this place would doubtless have placed Professor Pickering in the position to have made his ob-

* *Comp. Wochenschrift für Astronomie und Meteorologie*, year 1880 and following, H. Klein. *Anleitung zur Durchmusterung des Himmels*, 1880, p. 229 and following.

† *Wochenschrift*, 1882, p. 117 and following.

‡ *a. a. O.*, year 1880, and following.

servations of Messier, carried on under the favorable skies of Arequipa, with far better results, at any rate with a more definite purpose.

What Mädler said earlier, with so much emphasis, about the total agreement of both craters of Messier has not been proved in the least. I cannot conceive why Mädler should have asserted that there were projections to be found upon the ring walls of both craters, arranged so exactly alike, that one is reminded of a most singular play of chance. On the other hand, in my observations I was constantly contending with the uncertain appearance of both Messiers; I have hardly ever had a perfectly defined image of these in spite of years of observation, and I find from the remarks of Professor Pickering that this has repeatedly been his experience.

It would be strange indeed if this rested simply upon chance; Pickering imagines a kind of fog. I will take the occasion here to mention an observation of my own, through which I arrived at a similar conclusion. I have said of this in my guide for the survey of the sky, the following: "On the 1st of Nov. 1878, I found to my great surprise that the western ring mountain appeared shaped like a half moon, but the western edge was missing. There was an appearance there of something diffuse, the interior of the crater was like a half shadow. The eastern ring-mountain was sharply defined, complete, and the interior half filled with deep black shadow. On the following day also the western ring mountain was half-moon shaped, full of diffuse shadow. It was entirely impossible to see the western half-edge. I am convinced that a kind of fog lay in the interior of the crater at that time, and was spread out over the western half of the ring wall. Any other explanation of the invisibility does not seem to me admissible."

Professor Pickering is, to my knowledge, the first one who now proposes a similar explanation. He draws southeast near *A* the half ring of a secondary crater, whose diameter is somewhat smaller than that of *A*, and is of opinion that this half crater has not yet been noticed. This is, however, a mistake, for the attached half crater had been already seen July 2, 1870 and March 23, 1874, by Ingalls; then by me on March 23, 1882;¶ after this Feb. 18, 1885 by Saxby, and on April 19 of the same year by me again. Krieger also saw it and gave a representation of it upon plate II of his Moon Atlas, likewise upon plate VII in Sirius (year of 1894).

¶ *Sirius*, 1883, p. 174.

Here an opening is distinctly shown in the wall of *A* which leads into the connecting half crater. On plate XI of the great Moon chart of J. Schmidt the connecting crater and the wall opening are also indicated, but not very successfully. Pickering saw in the interior of Messier and of crater *A* little dark spots which he describes as variable; I have never seen these. Unfortunately it has escaped Professor Pickering that between Messier and *A* there is not a depression as in his drawing, but that a plateau arises there, and that *A* with its west wall, lies higher than the wall of Messier, whereby, at the proper position of the Sun a piece of the ring of the latter is covered by the shadow of the wall of *A*, so that Messier appears in a horse shoe like form. This was already beautifully seen by Gruithuisen Sept. 1, 1825 and I have had his sketch copied.‖ He says in explanation, "When the terminator (of the decreasing Moon) was distant only 2½ diameters of Messier from it, a half shadow of the eastern little circle (*A*) passed over the western (Messier) and the eastern one threw a shadow as far as the terminator." In the sketch this shadow extends broadly beyond Messier and the latter is shown as a faint oblong enclosure in this shadow. Professor Pickering gives at the close a comparison of his observations with each other. He says rightly that in a 3-inch refractor the variation in the relative size of the craters is very conspicuous. Two days after sunrise *A* appeared three times as large as Messier, on the next day it was seen four or five times as large; on the 9th day both craters appeared equally large. The explanation of this remarkable phenomenon seems to be a double one. On the 2d and 3d day after sunrise the outlines of Messier become mistily indistinct even in the 15-inch refractor, while *A* remains perfectly clear. In comparing the size of the crater in a small telescope, naturally, only that is considered which is clearly seen, therefore we compare the central parts of Messier with the edges of *A*. Secondly, the form of the interior of the craters is totally unlike. Messier has a long, narrow bottom, and gently declining sides, while the floor of *A* is broad, its walls falling off steeply, therefore *A* throws a broad strong shadow; Messier on the other hand, a narrower one, and the narrower such a shadow is the less black it appears. Since during the first few days after sunrise the inner surfaces of both craters are only a little brighter than the neighboring Mare, we judge of their relative sizes chiefly by the greater or less conspicuousness of their shadows, and therefore *A* appears as the larger. Later on

‖ *Wochenschrift für Astronomie*, 1881. p. 55.

the inner surfaces of both craters become much lighter than the Mare, while the shadows disappear, and now we see the craters more in their true relative magnitudes. Meanwhile one also finds even in a large telescope that the relative magnitudes of these craters vary, even if in a less degree than in a small one. Professor Pickering gives full tables of the forms observed by him, and the measured diameters of both craters and represents these by curves, arranged in order of the number of days elapsed since sunrise. According to this *A* is the largest at sunrise and sunset, at noon both are about of equal size, while Messier is the larger immediately before and after.

At first both craters are elliptical, later they are three-cornered and return to their elliptical form perhaps about two days after noon. Crater *A* (with its appendage) again appears three-cornered at sunset. A great resemblance of both craters in size, form and direction of their position-angle only takes place in a high position of the Sun between five and nine days after sunrise. Before noon *A* is more yellow, after noon of a greener color than its neighbor, at noon both are of the same color. The half crater attached to crater *A* on the southeast, is generally narrow before noon; after noon it appears larger; up to three days after sunrise, and as many days before sunset it is invisible. This invisibility arises chiefly because it can no longer be distinguished from the neighboring Mare; occasionally, its separation from *A* could not be recognized and it therefore appeared together with this one as one object. Concerning the brightness of the interior of the crater of Messier, this one increases with the rising Sun and it only begins to decrease with the 12th day. The interior of *A* grows still brighter than that of Messier, although more slowly. The surroundings of Messier, north and south, show a brightening and rapid increase of their intensity from the 2d day after sunrise; but shortly after noon it again decreases and on the 10th day has totally disappeared. Professor Pickering ascribes this to the formation of frost there. The shadow in the interior of Messier disappears between 7 and 7.4 days after sunrise and accordingly lasts until about noon, and as the Sun as seen from the Moon progresses 12° in one day the slope which throws this shadow must be nearly vertical. The inner eastern slope is far less steep, the shadow reappears in Messier in 12.7 days; in *A*, on the other hand, in 11.7 days after sunrise. The variable spot on the interior of the crater floor of Messier appears 2.6, in crater *A* 2.8 days after sunrise; both spots grow darker by degrees until the 4th day, then bleach slowly and by noon are

decidedly fainter. They were last seen on the 12th day after sunrise. Their breadth increases with the darkness and the spot in *A* was at the last nearly round.

"What now," says Pickering, "is the cause of all these changes which take place in these craters?" His answer is: "As far as I am concerned, I must candidly say that I do not know! For seven years I have studied these craters in the hope of solving the riddle. This solution may perhaps be very simple, but I am inclined to think that it will only be given by a skilled observer who is placed under more favorable conditions than those which are to be met in the northern hemisphere, with one or two exceptions. Careful drawings and measurements may then prove what is really going on, while the present observations show what is apparently going on."

After Professor Pickering had written the above, he succeeded in making an interesting observation on Nov. 21, 1898, 4.9 days after sunrise over Messier, in very clear air, with an enlargement of 550. From this it became probable that the semi-circle close to *A* on the southeast, which is seen after sunrise is not identical with a similar formation which is shown before sunset. When *A* appears elliptical the first mentioned semicircle is either distinguished from it, or vanishes in the Mare; when *A* on the other hand appears three-cornered its semicircle is combined with it, and the whole is shown as one crater. But this does not relieve the difficulties. The variable direction of the major axis of both elliptical craters of Messier and *A* is to be, at least, partially referred, according to Pickering to libration. This is likewise my opinion, but I find besides that both craters stand on the arched back of a broad flat ridge, one on its eastern, the other on its flank sloping to the west. Only in this way can the above mentioned changes in form and direction be explained.

Finally Professor Pickering points out* that the general opinion is surely erroneous that all portions of the Moon's surface appear equally clear and sharply defined in the same illumination. This same view I expressed and supported on the ground of my own observations 23 years ago†. But where Professor Pickering asserts, "The Moon's atmosphere is probably full of clouds, where we see a bright streak a cloud appears in a few days after sunrise, and it is principally the conspicuous presence of these in combination with the absence of shadows which make the details of many a Moon region, during full Moon so difficult of recognition," I should not like to concur in this opinion.

* *a. a. O.*, p. 254.

† *Sirius*, 1878, p. 54.

THE OBSERVATIONS OF COMETS AND METEORS.

W. F. DENNING, F. R. A. S.

There are few departments of astronomy presenting more diversity, more attraction, more mystery, and more need for further investigation than those relating to comets and meteors. Though very dissimilar in their visible aspects these objects are merely different forms of phenomena having an identity of origin. The meteor is but a detail or fragment of the comet, and in its fiery gleam, as it glides athwart the sky, we discern from a very near prospect, a portion of cometary material in process of combustion occasioned by the friction resulting from its impact with our atmosphere.

There is much to observe, much to discover in regard both to comets and meteors. A small telescope can be effectively employed upon comets, while in the observation of meteors the unassisted eye is sufficient. These fields of research are specially interesting from the fact that they are inexhaustible as regards the supply of large and brilliant objects previously unknown. Many other branches have now been so thoroughly explored that only small and insignificant members remain to be found, but brilliant comets and meteoric showers, hitherto unseen, will undoubtedly visit us in future years.

With respect to comets there are several features of useful work, viz., the search for and discovery of these bodies, the derivation of exact positions by micrometric measures, and the observation of physical details and changes. The systematic search for comets is one in which amateurs have often distinguished themselves, and is certainly more attractive than the mere routine work involved in the determination of places. For comet seeking a refractor of from 4 to 8 inches aperture, preferably of short focus, and with a glass prism at the eye end to facilitate convenience of observation, can be usefully employed. Or, if the reflecting form of telescope is preferred (and the writer would recommend it on account of the great ease with which observations may be conducted) one of from 5 to 10 inches aperture should be selected. Professor E. E. Barnard formerly used a 5 inch refractor, power 78, diameter of field 45′. Mr. W. R. Brooks began his cometary work with a 5 inch reflector, power 30, field 1½°, afterwards using an 8 inch reflector and finally a 10 inch refractor, power 40, field 1° 20′. Professor Lewis Swift employed a 4½ inch refractor, power 25, and field of 1½°. The writer when engaged

in similar work uses a 10 inch reflector, and one of three powers magnifying 32, 40, and 60, and with fields of 1¼°, 1°, and 50′. The observer must remember, however, that success must after all mainly depend upon himself. It will be measured by the patience and ability with which he pursues the work; the form or capacity of the instrument will prove quite a secondary factor. A really capable man may reap a plentiful harvest of discovery with inferior appliances, while a naturally poor observer will fail though his instruments are of the best quality.

The student in this field must of course possess a catalogue of nebulæ for reference, as he will encounter numbers of these objects which cannot at first sight be distinguished from small comets. When failing to identify a nebulous body its position should be noted relatively to small stars lying near it, and it should then be watched for traces of motion. This will usually become apparent in less than an hour if the object proves to be a comet. Its direction and rate of motion should then be determined as precisely as the observer's means permit, and an announcement of the discovery made by telegraph to the proper authority. Great care should always be taken that the object is really in motion, and, therefore, a veritable comet, and that its position does not correspond with that of any other similar object previously discovered.

As to the determination of exact positions this is effected by micrometric measurement from neighboring stars when the place of the comet is deduced from differential comparisons. For this work an equatorial is required, and the observer will need some comprehensive star catalogues. But the work of securing places of this character is regularly undertaken at a large number of observatories, so that, after a comet has been visible, for a few weeks, some hundreds of reliable positions are usually available for the determination of the orbit. Though it is certainly a great advantage to be in a position to obtain accurate places, if necessary, amateurs may safely as a rule leave this division of labor to their professional brethren whose equipment and training eminently qualify them to perform it satisfactorily.

The visible appearance of a comet is frequently very changeable and requires patient watching and drawing from night to night. The length of the tail, the character, apparent brightness and fluctuations in the light of the nucleus, the coma with its variations of form and density, etc., are all features needing attentive study and delineation. Of late years photography has been often employed in this department, and some excellent views of come-

tary structure have been obtained. This method is so efficient and so accurate in its portrayal of nature that it should be adopted when available in preference to other means.

The spectroscopic examination of comets comprises another interesting research in this field. The chemical constituents of these remarkable bodies appear to undergo some singular variations in condition during their approach to perihelion and recession from the Sun. It should obviously be the aim of the observer to critically watch these developments as they occur. Different comets appear to exhibit some marked differences in their spectra, due in part, no doubt, to changes in their positions relatively to the Sun. When commencing any researches of this kind the student would do well to make himself acquainted with the literature of the subject so that he may fully inform himself as to what has already been achieved, and as to the best appliances to be employed. The observer's action should, however, be, as far as consistent, independent of past experiences. A too careful study of previous work, and an absolute reliance upon past methods and results often have an unfavorable influence in preventing originality and destroy that open spirit and unbiased action which it is most desirable to foster in all true scientific inquiry.

Every year presents us with its comet or its comets. On an average there are five comets seen annually, and one of these will probably be visible to the naked eye. There are now so many short period comets known (belonging to the Jovian family and having periods ranging from 3.3 to 9 years) that there is usually one of them to be seen in a telescope, and about three of this group come to perihelion annually, though the number shows considerable variation. Thus during the five years, 1902 to 1906, inclusive the returns of 18 comets of short period are expected. In 1902 we may look for the reappearance of the following: Brooks (1886), Swift (1895), and Temple-Swift (1869-1880); and in 1903, Perrine (1896), Spitaler (1890), Faye and Brooks (1889). Several of these will probably elude re-detection owing to their unfavorable positions and small size, but they will no doubt be carefully looked for in the largest telescopes available, so that the necessary observations may be made on which to base a more accurate determination of their orbits.

Meteors have enlisted general interest in recent years and justly so, for their numbers and range are involved in their apparition. They probably pervade all space, in a complicated network of intermingled streams, pursuing cometary orbits and

forming the connecting links between suns and planets. Meteoric stones and irons, silent and detonating fireballs, meteors and the smaller shooting stars all indicate analogous phenomena, the apparent distinction being only one of size, or of the different conditions under which they are individually presented. The observation of these transitory objects offers a very important and productive field of research, limited to no particular time, season, or place, for their fall is incessant. The chief features of the work consist in recording their apparent paths as projected on the background of stars, and in estimating the durations of their flights. Unfortunately these points have to be determined by hurriedly made eye estimation, and are, therefore, only approximate. The transient life of meteors, in a luminous and visible form, is often comprised within a second of time, and so their positions cannot be brought under the refinements of instrumental measurement. But practice and care will enable the observer to register the apparent paths with a fair amount of precision, and the highest attainable accuracy in mapping the directions of their paths, forms the real key, as Professor A. S. Herschel has aptly said, to the solution of the problem presented by their nightly flights. The observer will find it an assistance in deriving correct positions, to hold a perfectly straight wand in the hand, and to project it upon the line of flight of a meteor instantly it appears. Then quickly directing the glance to regions near the backward and forward extension of the observed path he should note the direction and position of the meteor relatively to stars, and, reproducing the course upon a celestial globe or chart, he may read off the R. A. and Decl. of the beginning and end points. It is extremely difficult to correctly estimate the flight-durations of these rapidly-moving and fugitive bodies. But it is sometimes possible to form a good idea of the interval, brief as it is, and especially so in regard to the slower class of meteors. By repeating the letters of the alpaabet (at a rate ascertained by previous trials) during the flight and then noting the letter at which the meteor vanished the duration can be roughly ascertained. Thus, if the observer repeated six letters to the second, and had got as far as *l* during the meteor's visibility the duration would be two seconds. Numbers might be used instead of letters, and there are other plans which can be adopted. The writer sometimes used a stop watch with advantage, but such methods are inapplicable to the swifter class of meteors which often come and go before one can suitably deal with them. The direction of a meteor's flight is the principal

clue we have to the position of its radiant point, while its duration of visibility indicates the form of the orbit in which it is travelling, so that both features are important.

Whenever a fireball is seen the observer should immediately note its path amongst the stars and duration as accurately as possible. There are thousands of descriptions of fireballs published in the newspapers every year, but more than nine-tenths of them are practically useless for all scientific purposes because the observers omit to give the necessary details respecting the paths of the objects relatively to the stars. In addition to noting the paths and durations it is desirable to record other aspects accompanying meteors, such as phosphorescent streaks, spark trains, fluctuations of light, colors, variations of tint, etc., etc.

There are many interesting points concerning meteor showers which require further elucidation, and among these may be mentioned the following:

(1). The easterly motion exhibited by the radiant of the July-August Perseids, April Lyrids, and certain other showers.

(2). The stationary aspect and long duration of many radiant points, including the October Orionids.

(3). The actual visible durations of the chief periodical showers.

(4). The character of radiation in different cases, whether definite or diffused: In instances of diffusion, like that apparent in the Andromedids of November, the diameter and shape of the area should be ascertained if possible.

(5). The relative strength from year to year of showers which like the Leonlds periodically attain their maxima.

It seems desirable that the observer instead of looking specially for new and probably very feeble systems should investigate the leading features of old and prominent showers. To all painstaking and patient observers the meteoric department may still be regarded as rich in ungleaned facts, and this is particularly applicable to the southern hemisphere, which still remains practically unexplored.

The following are a few of the leading showers of the year:

Date.	Radiant. α °	Radiant. δ °	Name.	Meteors.
Jan. 2— 3	230	+ 53	Quadrantids	Rather swift.
Apr. 19—22	270	+ 33	Lyrids	Swift, streaks.
May 2— 6	338	— 2	η Aquarids	Swift, streaks.
July 27—30	339	— 10	δ Aquarids	Slow, long paths.
Aug. 9—13	45	+ 57	Perseids	Swift, streaks.
Oct. 18—23	92	+ 15	Orionids	Swift, streaks.
Nov. 13—15	150	+ 22	Leonids	Swift, streaks.
Nov. 17—23	24	+ 43	Andromedids	Very slow trains.
Dec. 9—12	108	+ 33	Geminids	Swift, short.

—*Knowledge, Diary and Scientific Handbook, 1902.*

THE NEW STAR OF 1901.*

H. C. WILSON.

The appearance of a new star, among the thousands which are visible to the naked eye on every starry night, may seem at first thought to be of very little importance. Yet if we stop to think that, according to our limited knowledge of them, all of the ordinary stars are bodies like the sun, gigantic in size, intensely hot, shining by their own light, across distances that stagger the imagination when we attempt to express their measures in ordinary units, it must seem that the sudden springing into existence of one of these, where there was none a few hours before, is a most startling event and one of intense interest to those who care at all to think on the mysteries of the structure and origin of our universe.

On the night of February 21, 1901, the Rev. T. D. Anderson, a retired Congregational minister of Edinburg, Scotland, who devotes much of his time to the study of and search for stars whose light is variable, noticed in the Constellation Perseus, a new star of the 2.7 magnitude, *i. e.* about half as bright as the pole star.

If you ask how he could recognize such a star as new, I will say simply by being familiar with the grouping of the bright stars of the constellation.

Probably any of you are so familiar with the principal stars of the Great Dipper that if a new bright star should appear within the bowl of the Dipper or anywhere in the handle of that figure you would at first glance notice that there was some change in the familiar group. Or if the well-known row of three bright stars in the Belt of Orion should receive the addition of a fourth equally bright or brighter, thousands of people not astronomers would be asking what the newcomer was. Let one take a little pains to become thoroughly acquainted with the groups of naked eye stars all over the sky,—and there is not as great a number of conspicuous stars as one might think, only some 300 which are at all conspicuous—and he may be able instantly to detect an intruder upon the regular order of the celestial array.

In this particular region the presence of the well-known variable star Algol made the detection of the new star more certain, for this variable every third day sinks from the second magnitude to the fourth, losing ¾ of its light for a few hours, then

* Read before the College Section of the Minnesota Educational Association, Dec. 27, 1901.

soon recovering its original brightness. Amateur astronomers all over the world are studying its light changes and it happened that on this very night two German astronomers, eight and seven hours before Mr. Anderson's discovery were comparing Algol with the neighboring stars for the purpose of estimating its brightness. They both claim that the new star was not then visible, at least not as bright as the fourth magnitude, for then they would have used it as a comparison star for Algol.

A young amateur, 16 years of age, in Russia claims to have observed the star nine hours earlier than Mr. Anderson and that it was then of the 1.5 magnitude or brighter than the pole star, but it seems pretty certain that he must have been mistaken in the date of his observation, for the brightness he gives is just what others give for the next night.

On the previous night, February 20, the region of the new star was photographed in England, and the photograph shows stars down to the 12th magnitude, but none is found in the place of the nova. Many earlier photographs taken at Harvard College Observatory and elsewhere, for several years back, all fail to show any trace of a star in the place of the new star. We must conclude, therefore, that it rose from invisibility in a moderate sized telescope to the brilliancy of a conspicuous naked eye star within 24 hours.

On the next night, Feb. 22, it had increased to the 1st magnitude and was independently discovered by perhaps a score of individuals in various parts of the world.

Telegraphic announcements set all the astronomers at work studying the phenomena of the new comer, with the great variety of powerful and delicate apparatus now on hand and this star has been studied as none of its predecessors have ever been.

On the next night, Feb. 23, it reached its maximum brilliancy, about equal to that of the stars Vega and Capella. It then waned slowly for three weeks with slight fluctuations, when something happened which caused a periodic oscillation of its light.

I have taken great pains to collect all of the published observations of the light and color of the star up to the present time and a complete list of them is being published in the current numbers of POPULAR ASTRONOMY. The number of observations now on hand is approaching 2,000. On the chart which is placed before you,* all the observations for which the exact times were stated are platted to scale, and a smooth curve drawn through them so

* The chart was published in POPULAR ASTRONOMY, November, 1901.

that it represents graphically the fluctuations of the light of the star between Feb. 21 and April 25.

The striking features of this light curve are the steepness of its rise on Feb. 21 and 22, the maximum on Feb. 23, the gradual decline to March 18, and the great and irregular fluctuations after that date. These fluctuations continued through May and June, the intervals between the maxima or high points of the curve gradually lengthening and their height lessening until in August they were hardly noticeable. The star is still visible with a field glass and is likely to remain visible in powerful telescopes for years to come.

The question immediately arises, what is the explanation of this sudden apparition? Is it the birth of a new star destined to become a permanent member of the sidereal system, or is it one of the incidents of the later life of a celestial body, a sign of decline, of old age, of a body which has long since lost its light by radiation, now temporarily revived by the breaking of its shrunken crust and the bursting forth of its molten interior? Is it of the regular order of cosmic events or is it simply a catastrophe, wholly aside from the regular order?

Before attempting to answer these questions let me go on to state a few more of the facts which have been learned about this star.

Accompanying the changes of brightness of the Nova there have been changes of color. It is somewhat difficult to get at the exact colors, because of the different color perceptions of the observers and the different instruments employed, but the changes seem to have been these:

At the first and at the time of greatest brightness the color was white or bluish white; as it declined it passed through yellow, orange and light red to dark red, *i. e.*, just the order of colors assumed by a body while cooling off from an intense heat. In March and April when the great fluctuations of light occurred, the color also fluctuated between whitish yellow and dull red. It was invariably dull red when faintest and yellowish or whitish when at a maximum. As the fluctuations died out the color became more of a greenish tint.

One of the German astronomers has, by representing the different colors by numbers according to their position in the spectrum constructed a color curve which resembles very much the light curve which is before you.

This color change is therefore one of the factors of which account must be taken in explaining the phenomena of the star.

There were also, coincident with the changes of color and brightness, changes in the spectrum of the star.

I must not attempt to go very far into this subject, but, briefly, at first the spectrum was almost continuous, *i. e.*, it was that of an incandescent solid or liquid, or of a glowing gas under very great pressure. As the brightness began to decline, dark lines appeared in the spectrum, indicating that cooler gases were absorbing part of the light. These dark lines, due to absorption, gradually increased until finally there were left only a few bright spaces, almost too broad to be called lines, yet occupying the places of the bright lines in the spectrum of the gas hydrogen and the unknown gas which with hydrogen composes those mysterious shining clouds of matter, found here and there in great numbers in the sky, called nebulæ. In fact the spectrum of the star has changed into that of a nebula.

And herein is one of the best keys to the solution of the problem. Not very many new stars have been observed, only some 40 in all in 2,000 years, the most conspicuous of all being those of Tycho Brahe in 1572 and Kepler in 1604. During the last century a dozen have been discovered and half of these perhaps have been studied with the spectroscope. The important point which I wish to bring out is that, as a rule, those whose spectra have been studied have ended by becoming nebulæ, so far as spectroscopic evidence determines, although in the telescope they retained the aspect of stellar points. According to the old nebular hypothesis all of the celestial bodies, stars, Sun, Moon, planets and satellites, were formed by the condensation, into various centers, of a nebulous fluid which originally filled all stellar space. Such formation of stars, however, must have occupied immense ages in its process, and does not account directly for such sudden apparitions as that of a new star.

It may be modified by supposing that some of the nebulous matter was not drawn into the centers which are now visible but is now moving in great streams through the spaces between the stars. Now and then such streams of dark matter may run into each other or they may come under the dominant influence of a single star and be partially drawn into it by the force of gravity. It is calculated that a particle drawn from a practically infinite distance into the Sun would acquire on reaching the Sun's surface a velocity of 382 miles per second.

The meteors which enter the Earth's atmosphere have velocities of from 10 to 40 miles per second. The friction with the air due to even this speed causes the meteor to flash up and be con-

sumed in a second or two. A *great* meteor may last for several seconds and produce a light approximating that of the Sun. The heat thus generated is given to the atmosphere of the Earth. Imagine then a swarm of millions of millions of such meteors with velocities multiplied 10 to 30-fold and one may gain some conception of what might happen should a giant body like the Sun encounter an enormous meteoric stream or nebula. A dark sun might thus have its atmosphere heated to intense incandescence and its surface "melted with the fervent heat?"

After the swarm had passed the heat would be rapidly absorbed by the cold body, as well as radiated into space; the vapors of the substances cooling first would absorb the light passing through them and at the last there would be mainly the glow from those substances which are luminous at the lowest temperatures, viz., the elements of the nebulæ.

Professor Lockyer, the English astronomer at Kew Observatory, explains the new star as the result of the collision of two meteoric streams crossing each other, the impact of myriads of pairs of meteors with tremendous velocities generating heat and liberating and rendering luminous for a time the various vapors. Indeed he accounts for nearly all celestial phenomena by means of his "Meteoritic Hypothesis," for which there are some very strong arguments and to which there are some serious objections, which cannot be discussed here.

It is certainly an interesting thought that through all space there are such streams of matter gliding swiftly though unseen, which may at any moment come into collision with each other or with the known stars and nebulæ. It is much more probable that such an enormously extended aggregation of matter should intersect the path of another than that two relatively smaller bodies like the Sun should meet, as required by one of the suggested explanations of the new star. The chances that two suns in motion should run into each other cannot be one in a million.

There is another reason why the collision theory of two suns is an improbable explanation of temporary stars and that is that the effect produced should not be so transient. Dr. Croll in his book "Stellar Evolution and Its Relations to Geological Time," published in 1889, calculated that for two bodies each one-half of the mass of the Sun, moving directly toward each other, the velocity of impact would be 476 miles per second and the result of the collision would be the development of an amount of heat which would satisfactorily account for the present rate of the Sun's radiation for a period of fifty millions of years. He

computes that the gas developed at the moment of collision would have a temperature of about 300,000,000 degrees centigrade, or more than 140,000 times that of the voltaic arc. The light from such a collision could not fade away to invisibility in a few days, weeks or months, from the radiation of its heat. Yet the same thing might happen from another cause. Matter becomes invisible by reason of increase of temperature as well as from the loss of heat.

According to Dr. Croll "the first result of such a collision would be the shattering of both bodies into a number of fragments, which by their subsequent collisions inter se would be reduced to smaller fragments and these again by the same process into smaller fragments still, which acted upon by the enormous heat of the generated gas would gradually become gaseous also, so that in the course of time the whole would assume the gaseous condition, and we should then have a perfect nebula—intensely hot but not very luminous." This explanation cannot hold in the present case for the color changes should be from white to blue instead of toward the red as the observations indicate.

I wish now to call your attention to the appearance of the hydrogen lines of the star's spectrum. Instead of being fine and sharply defined, as in the spectrum of hydrogen in the laboratory they are very broad and composed of three bright and three dark portions. Now, according to Doppler's principle in Physics, if the source of light is approaching the observer the waves of ether, which produce the sensation upon the eye of the observer or upon the sensitive plate, are shortened and so in the spectrum the lines are shifted a little toward the blue end. If the light source is receding the waves are lengenthened and the spectral lines are consequently shifted toward the red.

We may explain the widening of the lines in this case as the result of approaching and receding sources of light at the same time. This would be the truth in the case of two bodies in collision or of two intersecting meteor swarms, for the heated fragments would fly in all possible directions with a very great range of velocities in the line of sight.

The gases flying most swiftly outward would be the first to cool off and those coming directly toward the Earth would be most effective in absorbing the light from the central portions. We should then find an absorption line on the side toward the blue of each line but none toward the red, which is the observed fact in the case of this star, and the bright line should be broad-

ened because of the light coming from particles moving both to and from us with the entire range of velocities. The superposition of the various effects of emission and absorption might produce maxima in different parts of the broadened line so as to give it the triple appearance which is observed.

From the displacements of the different parts of the line with reference to that of stationary hydrogen, it is possible to calculate the velocities of the light sources to which they owe their origin, and we find these to come out astonishingly large. Although the middle of the bright line coincides very nearly with the laboratory line of hydrogen, indicating that the average of the mass is receding from us at about four or five miles a second, the edges are so far displaced that it is necessary to assume velocities of from 700 to 1000 miles per second, to and from us, in order to account for them.

Are such velocities possible?

Yes, it is only necessary to suppose one of the colliding bodies to have a little more than six times the mass of the Sun, condensed into the same volume, and gravity alone would give a velocity of 1000 miles per second to a particle falling into it from an immense distance. The velocity of the debris flying off from the explosion, or partial explosion, of such a body cannot be calculated, but we may reasonably infer that it would be tremendous.

I now come to the latest and most wonderful fact which has been discovered concerning this star and one which is destined, when properly interpreted, to assist greatly in the solution of the problem.

The star has at no time shown any trace of nebulosity when viewed with the most powerful telescope, but in August the French astronomer Flammarion and his assistant Antionadi announced that their photographs showed an aureole around the new star, which was not exhibited by other stars of equal brightness. This aureole was shown by other astronomers not to be truly nebulous, but to be due to an extraordinary amount of light of a wavelength for which the telescope lens was not corrected. But it set astronomers to work again upon the attempt to photograph the supposed nebula and on Sept. 20 Mr. G. W. Ritchey, of the Yerkes Observatory, succeeded with a two-foot reflecting telescope, by an exposure of nearly four hours, in photographing an exceedingly faint but real nebula, surrounding the new star, thus proving that there was a nebula in connection with what before had been known to be nebulous only because of

its spectrum. This nebula was nearly circular, with the star in its center, and its appearance is quite suggestive of envelopes of gas thrown off from the star by a succession of explosions.

Still more remarkable is the discovery made six weeks later by Mr. Perrine at the Lick Observatory. Upon photographing this star with the 36-inch Crossley reflector with a long exposure, he not only verified the details of the nebula, but found by comparison with Mr. Ritchey's photograph that the most conspicuous parts of the nebula *were moving* so rapidly that in six weeks the motion was plainly visible to the eye upon the photographs. Now this is the more remarkable from the fact that in no case hitherto has any motion been detected with certainty in any of the nebulæ, by the most careful measurements made at intervals of many years, while here is a motion of a whole minute of arc in six weeks.

It is clear that we have something different from the ordinary nebula. Again, the motion of the principal outer knots of nebulosity carried back to Feb. 21 would bring them in the close vicinity of the star, so that the conclusion is almost irresistible that they are the results of a titanic eruption from the star.

Assuming that the velocities of these fragments of nebula are not greater than of the matter whose light produces the broadening of the lines in the spectrum of the star, *i. e.* 1000 miles per second, I have computed the maximum distance of the star from the Sun and find it to be 12½ trillions of miles or just half the distance of the nearest star whose parallax has been determined. If so its parallax ought to be twice as great as that of α Centauri or about 1″.5. It is too early yet to have determined the exact parallax of this star but the only report concerning it which I have yet received indicates that the parallax is very small and hence the star is much farther away than I have computed. If so the motions of the nebulous patches must be enormous, several thousands instead of one thousand miles per second, and our conception of the magnitude of the catastrophe which gave rise to the star must be vastly increased.

Perhaps the best explanation of the apparition of a new star is not that of an actual collision between two bodies or of two swarms of bodies, but rather that of a near approach of two dark suns so near that the tidal action of one upon the other, or of both upon each other, shall draw away the dense atmospheres from portions of this surface, and even break open the crust, letting out the pent-up forces of the molten matter from within. Such an action would not cease with the first eruption but there

would be set up an oscillatory reflex tidal action which might cause many successive eruptions, thus explaining the fluctuations of light.

There are thousands of double stars in the heavens which revolve about each other in very elongated paths, so that a revolution occupies hundreds of years, and which at their periastra, or nearest points, approach very close to each other, and it takes no great stretch of the imagination to suppose that there are many similar dark pairs which may on rare occasions come near enough to produce the effects required for the phenomena of temporary stars. Almost all of the classes of variable stars may be explained by similar hypotheses and it may be that the so-called new stars are but one class of variables of exceedingly long periods.

A STAR-CORRECTION MACHINE.

D. T. WILSON.

For Popular Astronomy.

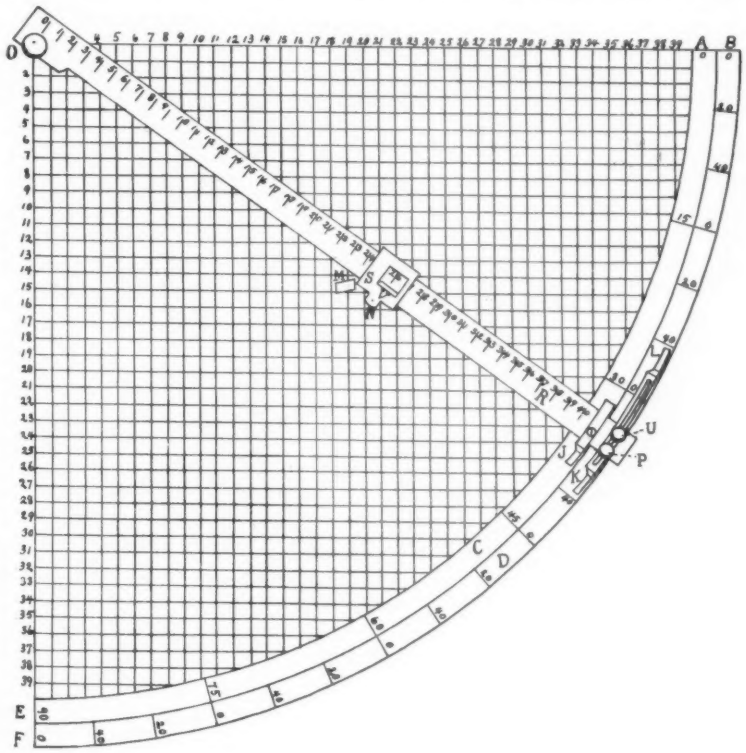
As is well known, all meridian circle observations must be reduced to the mean place of the Earth for the beginning of the year in which the observations are made. For this purpose the corrections to be applied to the observed right ascension and declination are determined by means of the two following equations:

$$-\Delta\alpha = f + g \sin(G + \alpha) \tan\delta + h \sin(H + \alpha) \sec\delta$$
$$-\Delta\delta = g \cos(G + \alpha) + h \cos(H + \alpha) \sin\delta + i \cos\delta,$$

where f, g, h, i, G, H, are the independent star-numbers of the *American Ephemeris* and α and δ are the observed right ascension and declination of the star. For an evening's work of three hours the star-numbers may be regarded as constants. The computation required for the solution of the above equations is quite simple but tedious and uninteresting. While doing this computing for the meridian circle observations of the Cincinnati Observatory it occurred to me that it was machine work and that a machine could be constructed which would do it to the required degree of accuracy. The machine was made and thoroughly tested by myself. I give herewith a description of it and some results of its work.

AOE is a quadrantal brass plate screwed to a smooth board. ACE is an arc of 90° divided to ten minutes of arc with centre at O and with radius of forty centimetres. Concentric and con-

terminal with ACE is another arc BDF of forty-three centimetres radius and divided to minutes of time. On this arc the minutes are marked from zero up to sixty but not the hours. At O is pivoted the straight-edged ruler OR graduated in millimetres with the centimetre as the unit, which represents a second of arc, the unit in which *g*, *h*, and *i* are expressed. It is broader at the pivot so that the centre of the pivot hole may be outside the line



THE STAR-CORRECTION MACHINE.

of the straight edge. The surface is ruled in parallel lines and numbered to correspond with the divisions and numbers on the ruler when it is at either end of the arc. The initial lines OA and OE are drawn from the centre to the ends of the arc. J is a vernier of ten divisions attached to the ruler by which settings can be made to one minute on the arc ACE. K is a vernier of twelve divisions by which settings can be made to five seconds on

the arc BDF. S is a slide carrying a needle-point N, pointing vertically downward almost to the surface, and carrying also a vernier V by which settings can be made on the ruler to one one-hundredth of a second of arc. The needle-point and vernier J are adjustable. They are placed by trial the same distance from the straight edge as the centre of the pivot, so that the zero of vernier J the needle-point and the centre of the pivot are always in a line while the slide moves along the ruler. For convenience of reading I have made this distance about five millimetres. U is a screw for clamping the ruler and P is one for clamping vernier K.

It is clear that if vernier J is set to the angle X and vernier V to the value x on the ruler the distance of the needle-point from the initial line OA (read off on the margin OE) will be $x \sin X$ and its distance from OE will be $x \cos X$. In making the computations for which the machine was designed the functions of the right ascension are obtained first. Vernier K is adjustable. Before beginning on a set of observations vernier J is placed at a zero minute (0°, 15° or 30°) and clamped. Vernier K is then set at a value sixty minutes less the number of minutes and seconds in G and clamped. The ruler is then unclamped and placed approximately to the value $G + \alpha$. K is then placed on the nearest minute and second of α. V is set to the value g. Then the angle AOJ is the angle $G + \alpha$, and the position of the needle-point, which may be estimated to tenths of a millimetre or hundredths of a second of arc, will indicate the value of the sine and cosine of $G + \alpha$. Since stars are observed in the order of right ascension it will not be necessary to take any further notice of G, for setting vernier K to the value of each right ascension in the order observed the sine and cosine of the sum are at once read off on the margins. If the sum $G + \alpha$ should exceed six hours it can be reduced to the first quadrant by ordinary trigonometry without delay or comparison. The functions of $H + \alpha$ are obtained in the same way.

The functions of $G + \alpha$ and $H + \alpha$ thus obtained, except $g \cos (G + \alpha)$, and the constant i are to be multiplied by the tangent secant, sine and cosine of the declination. This is easily and rapidly done. Set vernier J to the value of the declination and clamp. Move slide until the needle-point marks a distance from OE equal to the value $g \sin (G + \alpha)$. Then the distance of the needle-point from OA is the value in seconds of arc of $g \sin (G + \alpha) \tan \delta$. To get the next term set the needle-point at a distance from OE equal to $h \sin (H + \alpha)$. Vernier V will then indicate the value of $h \sin (H + \alpha) \sec \delta$. Similarly $h \cos (H + \alpha) \sin \delta$

and $i \cos \delta$ are obtained. The whole operation requires much less time than the usual method and the result is freer from accidental errors. By means of the mirror M which moves with the slide S and is easily placed at an angle of 45° with the lines the position of the needle-point with respect to the transverse lines may be easily and accurately read without moving. Vernier L follows at a known distance behind K and is used when K runs off the arc at F.

Below are some computations made with the machine compared with those made with logarithms. These results are taken from the regular sheets of this Observatory and are selected with a view to getting as wide a range of declination as possible. In no case has the original reading of the machine, which was made independently and without knowledge of the correct result, been changed unless it was clearly a mistake of the operator and not of the machine. Only a few such errors were found. In most cases where there was a discrepancy the error was in the logarithmic computation.

α	19 h 11.7 m	19 h 13.8 m	19 h 20.3 m	19 h 22.0 m	19 h 13.0 m
δ	4° 40′	+ 0° 10′	11° 44′	19° 54′	− 0° 7′
$g \sin (G + \alpha) \tan \delta$ log.	− 1.35	− 0.05	− 3.35	− 5.80	+ 0.05
" " " " " " Mach.	− 1.34	− 0.03	− 3.33	− 5.80	+ 0.04
$h \sin (H + \alpha) \sec \delta$ log.	+ 7.31	7.46	8.10	8.55	8.71
" " " " " " Mach.	+ 7.32	7.47	8.11	8.57	8.74
$\Delta\alpha$ log.	+ 3.359	3.456	3.279	3.145	3.546
" Mach.	+ 3.361	3.458	3.281	3.147	3.547
$g \cos (G + \alpha)$ log.	+11.58	11.74	12.20	12.30	12.93
" " " " Mach.	11.60	11.75	12.21	12.33	12.95
$h \cos (H + \alpha) \sin \delta$ log.	1.41	0.05	3.46	5.77	− 0.05
" " " " " " Mach.	1.40	0.02	3.45	5.77	− 0.03
$i \cos \delta$ log.	8.09	8.11	7.94	7.63	8.11
" " " Mach.	8.09	8.11	7.93	7.61	8.11
$\Delta\delta$ log.	21.08	19.90	23.60	25.70	20.99
" Mach.	21.09	19.88	23.59	25.71	21.03
α	19 h 35.7 m	19 h 38.0 m	19 h 40.0 m	19 h 46.6 m	19 h 1.0 m
δ	17° 48′	8° 9′	13° 0′	19° 48′	37° 58′
$g \sin (G + \alpha) \tan \delta$ log.	− 4.90	− 2.16	− 3.46	− 5.26	−12.91
" " " " " " Mach.	− 4.89	− 2.14	− 3.46	− 5.26	−12.90
$h \sin (H + \alpha) \sec \delta$ log.	9.51	9.32	9.61	10.44	14.50
" " " " " " Mach.	9.54	9.30	9.64	10.47	14.50
$\Delta\alpha$ log.	3.269	3.439	3.372	3.307	2.982
" Mach.	3.272	3.439	3.374	3.309	2.983
$g \cos (G + \alpha)$ log.	13.25	13.40	13.53	13.96	10.58
" " " " Mach.	13.26	13.42	13.54	13.96	10.60
$h \cos (H + \alpha) \delta$ log.	5.03	2.32	3.66	5.42	9.31
" " " " " " Mach.	5.01	2.30	3.64	5.42	9.34
$i \cos \delta$ log.	7.72	8.03	7.90	7.63	6.03
" " " Mach.	7.72	8.03	7.90	7.63	6.02
$\Delta\delta$ log.	26.00	23.75	25.09	27.01	25.92
" Mach.	25.98	23.75	25.08	27.01	25.96

	h m	h m	h m	h m	h m
α	19 20.6	19 22.6	19 26.0	19 28.2	19 49.1
δ	36° 16′	36° 8′	36° 5′	28° 4′	20° 5′
$g \sin (G+\alpha) \tan \delta$ log.	−11.43	−11.30	−11.14	− 8.09	− 5.11
" " " " " " mach.	−11.42	−11.30	−11.12	− 8.09	− 5.10
$h \sin (H+\alpha) \sec \delta$ log.	15.72	15.86	16.10	14.89	15.26
" " " " " " mach.	15.73	15.88	16.12	14.91	15.28
$\Delta\alpha$ log.	3.162	3.180	3.207	3 329	3.553
" mach.	3.163	6.181	3.209	3.331	3.555
$g \cos (G+\alpha)$ log.	11.95	12.09	12.32	12.46	13.79
" " " " mach.	11.97	12.11	12.32	12.48	13.80
$h \cos (H+\alpha) \sin \delta$ log.	8.34	8.25	8.13	6.44	4.27
" " " " " " mach.	8.36	8.26	8.14	6.42	4.27
$i \cos \delta$ log.	6.15	6.17	6.17	6.73	7.18
" " " mach.	6.17	6.18	6.17	6.74	7.18
$\Delta\delta$ log.	26.44	26.51	26.62	25.63	25.24
" mach.	26.50	26.55	26.63	25.64	25.25

	h m	h m	h m	h m	h m
α	18 37.8	18 41.2	18 44.4	18 45.5	18 49.6
δ	72° 18′ 0″	55° 57′ 30″	61° 50′ 30″	59° 13′ 35″	75° 19′ 30
$g \sin (G+\alpha) \tan \delta$ log.	−55.20	−25.90	−32.54	−29.07	−65.43
" " " " " " mach.	−55.20	−25.87	−32.53	−29.04	−65.37
$h \sin (H+\alpha) \sec \delta$ log.	30.30	16.90	20.38	19.07	39.66
" " " " " " mach.	30.34	16.91	20.40	19.08	39.72
$\Delta\alpha$ log.	1.230	2.290	2.079	2.223	1.176
" mach.	1.233	2.293	2.081	2.226	1.180
$g \cos (G+\alpha)$ log.	8.93	9.20	9.38	9.53	9.84
" " " " mach.	8.95	9.21	9.40	9.54	9.85
$h \cos (H+\alpha) \sin \delta$ log.	15.73	13.63	14.37	13.93	15.50
" " " " " " mach.	15.76	13.61	14.40	13.94	15.52
$i \cos \delta$ log.	2.35	4.32	3.65	3.95	1.95
" " " mach.	2.36	4.33	3.64	3.96	1.95
$\Delta\delta$ log.	27.01	27.15	27.40	27.41	27.30
" mach.	27.07	27.15	27.44	27.44	27.32

	h m	h m	h m	h m	h m
α	19 14.2	22 26.1	19 27.7	19 32.6	7 40.0
δ	65° 6′ 15″	78° 17′ 20″	79° 24′ 20″	69° 30′ 0″	80° 30′ 20″
$g \sin (G+\alpha) \tan \delta$ log.	−34.47	−11.58	−83.98	−43.26	+94.06
" " " " " " mach.	−34.48	−11.48	−83.82	−43.26	+94.02
$h \sin (H+\alpha) \sec \delta$ log.	27.84	79.93	46.11	+ 4.44	−13.13
" " " " " " mach.	27.86	78.91	45.96	+ 4.45	−13.04
$\Delta\alpha$ log.	2.448	7.517	0.437	0.502	8.485
" mach.	2.449	7.515	0.438	0.503	8.488
$g \cos (G+\alpha)$ log.	11.61	20.44	12.71	13.44	13.96
" " " " mach.	11.63	20.44	12.71	13.42	13.94
$h \cos (H+\alpha) \sin \delta$ log.	13.48	9.57	16.46	17.65	18.53
" " " " " " mach.	13.50	9.59	16.46	17.64	18.51
$i \cos \delta$ log.	3.25	1.64	1.49	2.72	1.28
" " " mach.	3.26	1.64	1.51	2.73	1.28
$\Delta\delta$ log.	28.34	31.65	30.66	33.81	23.77
" mach.	28.39	31.67	30.68	33.79	23.73

	α	h 21	m 25.9	h 1	m 7.9	h 3	m 53.8	h 1	m 34.8	h 2	m 16.8
	δ	66°	23′ 10″	79°	23′ 40″	80°	25′ 50′	40°	5′	41°	2′
$g \sin(G+\alpha) \tan \delta$ log.		−17.98		+75.08		+142.34		12.68		15.58	
" " " " " " mach.		−18.03		+75.31		+142.05		12.70		15.59	
$h \sin(H+\alpha) \sec \delta$ log.		25.75		46.67		112.36		22.46		24.78	
" " " " " " mach.		25.79		46.77		112.29		22.49		24.80	
$\Delta\alpha$ log.		3.608		11.730		20.593		5.667		6.005	
" mach.		3.607		11.752		20.569		5.650		6.007	
$g \cos(G+\alpha)$ log.		19.50		20.34		5.93		16.99		13.96	
" " " " mach.		19.48		20.31		5.93		16.97		13.94	
$h \cos(H+\alpha) \sin \delta$ log.		14.52		18.20		8.07		6.33		4.28	
" " " " " " mach.		14.51		18.18		8.10		6.30		4.29	
$i \cos \delta$ log.		3.12		0.22		0.20		3.91		3.86	
" " " mach.		3.12		0.22		0.20		3.90		3.86	
$\Delta\delta$ log.		27.14		38.76		14.20		27.23		22.10	
" mach.		27.11		38.71		14.23		27.17		22.09	

A study of the above table shows that for declination not exceeding 40° the maximum error in right ascension is $0^s.003$ and in declination 0″.06. For declinations between 40° and 78° the maximum error is $0^s.006$ and 0″.06 respectively while for declination between 78° and 81° it is $0^s.024$ and 0″.05.

It will be seen from the construction ot the machine that the greatest errors will be in the two terms involving tan δ and sec δ for large values of the declination. The maximum value of the co-efficient of tan δ and of sec δ is about 28.1. For this value of the co-efficients the terms can be read off on the machine for all declinations up to 45°. For greater declinations a short computation must be made. The greatest reading of the machine: the final result: the maximum value of the co-efficient: the radius of the circle that is, the distance of the needle point from OE. This computation multiplies the error of reading which itself is larger than for small declinations. However the discrepancy is not large, as will be seen from the following table:

δ	30	35	40	45	50
28.1 tan δ log.	16.22	19.68	23.58	28.10	33.49
" " " mach.	16.22	19.68	23.56	28.09	33.47
28.1 sec δ log.	32.45	34.30	36.68	39.74	43.72
" " " mach.	32.46	34.33	36.71	39.76	43.73
28.1 tan δ + 28.1 sec δ log.	48.67	53.98	60.26	67.84	77.21
" " " " " " mach.	48.68	54.01	60.27	67.85	77.20
In time log.	3.245	3.599	4.017	4.523	5.147
" " mach.	3.245	3.601	4.018	4.523	5.147

δ	55	60	65	70	75
28.1 tan δ log.	40.13	48.67	60.26	77.20	104.87
" " " mach.	14.12	48.63	60.23	77.11	104.79
28.1 sec δ log.	48.99	56.20	66.49	82.16	108.57
" " " mach.	49.03	56.20	66.50	82.11	108.55
28.1 tan δ + 28.1 sec δ log.	89.12	104.87	126.75	159.36	213.44
" " " " " " mach.	89.15	104.83	126.73	159.22	213.34
In time log.	5.941	6.991	8.450	10.624	14.229
" " mach.	5.943	6.989	8.449	10.615	14.223

From all these comparisons and from a great number made in computing but not given here, I think it safe to say that the machine may be relied upon to make computations correct to one one-hundredth of a second of time for all declinations up to 75°.

I have used the reticuled surface and the division of the hour are suggested by Mr. W. E. Cooke (*Monthly Notices*, R. A. S., vol, LV, p. 288). For the successful ruling of the surface I am indebted to Mr. John J. Clegg, of the firm of Clegg, Goeser, McFee & Co., engravers, Cincinnati, Ohio.

CINCINNATI OBSERVATORY.

THE SO-CALLED ICE AGE.

LEWIS SWIFT, F. R. A. S.

FOR POPULAR ASTRONOMY.

Time was when it was true, and to a certain extent it still is, that one could hardly take up a scientific journal, without being confronted with the statement that this or that event occurred, since, or before, or during the glacial epoch. Being a disbeliever that there ever existed in the heavens above or Earth beneath a cause for such a severe and prolonged frigidity, I have concluded to ventilate my views on the subject, both from astronomical and terrestrial standpoints in order to combat a delusion that is wide spread. I have long been hoping that it, like many others that have existed, would die a natural death, but this seems to be very tenacious of life.

I ask what are the facts in favor of the strange idea, that the northern hemisphere was once covered with a layer of solid ice that extended entirely round the Earth from the pole, well nigh down to the equator, or as one glacialist says, five miles in thickness in Florida? In my opinion there are none, but on the contrary there are overwhelming evidences against it, which volumes of valueless theories cannot overthrow. A complete elucidation of so extensive a subject however, requires more space than can be allotted to me here.

The eccentricity of the Earth's orbit is slowly changing; in our age decreasing, and will continue to for thousands of years when a change to an increase will commence, without the orbit ever arising to a circle. The Sun occupies one of the two foci of the ellipse.

Whether the eccentricity is at a maximum or minimum, there would be no change in the Earth's temperature as a whole, or a perceptible change in its northern half as a part.

Suppose for instance, that when its maximum eccentricity occurred, the Earth should happen to be in aphelion during our northern winter, it of course would be slightly cooler, but in six months it would be in perihelion, when the northern half would be as much warmer as its winter half was colder.

There are other changes going on called the variation in the obliquity of the ecliptic, but they are confined in very narrow limits, and require many thousands of years for their completion. Whether at a maximum or minimum, the temperature both north and south, will vary through narrow limits alternately during the year.

Its maximum obliquity is	24°	35′	58″
Minimum is	21	58	36
	2	37	22

Its mean obliquity for 1901 = 23° 27′ 6″.7.

Everybody knows that the Earth revolves around the Sun in an orbit, but all do not know that the orbit also revolves once in 109,830 years. This of itself would produce no change in the Sun's heat imparted to the Earth, but coupled with the precession of the equinoxes, it changes the seasons from north to south and *vice versa* in 10,750 years instead of 12,900 years, or half the precessional period. In our age, the Earth is in perihelion on January 1st, and in aphelion on July 2nd, and being nearest the Sun in our winter, causes it to be slightly warmer, but being in aphelion during our summer six months later, causes it to be just as much colder.

We have no evidence that there has been any change in the Sun's intensity, but if there has, it is reasonable to believe that in ancient geological eras, his intensity must have been greater than now. This is another argument against the glacialists, and this, coupled with the Earth's internal heat which at that time must have been nearer the surface than now, furnishes overwhelming proof that there never was a glacial epoch, nor ever will be till the Sun's heat declines. The petrified forests in the northwest, furnish abundant proof that the intensity of the Sun's heat at that time, must have been almost, if not exactly, the same as in our age, proving that the Sun's heat is a constant quantity.

I will now briefly allude to another subject, which strikes a death knell to the ice age delusion. For the sake of argument I will assume that there once existed such a northern frigidity as is claimed, and that the northern half of the northern hemisphere

was for ages covered with an ice cap from one to five miles in thickness, frozen to the solid ice of the Arctic ocean, and that ocean frozen to its solid bottom, and to the Earth, covering if it extended to Lat. 45° nearly 62,500,000 square miles—one solid mass of unyielding ice.

From the north pole every way except towards the zenith and nadir, is south, and for it to move an inch, this mass of ice must have been broken into fragments, which no power but earthquakes could accomplish. (This possibility I admit, but doubt its probability).

Now the glacialists contend, that this vast mass of ice all round the Earth, moved toward the equator. Where, I ask, existed the power that could move it an inch, over hills and through valleys, frozen as the imaginary fragments were to the Earth? There is an ice cap there today—why does not that move?

It is a fact of general observation, that the northern part of the northern hemisphere is strewn with bowlders, some of them of immense size; all admit these are foreigners. It is a question of mighty import as to where they came from, and by what power they were transported and deposited on the north side of elevations. There is but one cause that can for an instant stand the test of investigation. This is, that where the entire Earth was covered with water, they were transported by icebergs, and dropped as the ice melted. This process is going on today.

An ice berg is the broken-off lower end of a glacier, formed on the sides of high mountains; these glaciers slide in channels down the mountain sides at the rate of about one foot a day. They are loaded with masses of stone, rough and angular, which have fallen upon them from the mountains. By the attrition of sand and water during countless ages the asperities of these stones were all worn off, and they became polished.

[TO BE CONTINUED].

At the last moment I add a note of admiration for Professor Kapteyn's brilliant suggestion with regard to Nova Persei in *Astr. Nach.* No. 3756. He points out that the velocity with which the nebula is apparently expanding will be the same as that of light if the parallax be not greater than 0″.01; and he suggests that the expansion is not that of actual matter, but merely that of the boundary which the light has reached in the months subsequent to the flaring up, before being reflected back to us. If an explosion takes place in a hilly country, we hear the echoes from more and more distant hills in the order of distance, and we are now perhaps *seeing* the *light echoes* of the flare up of last February. The hypothesis fits the known facts with a striking completeness so far, and adds another sensation to the many which the star has already afforded.—From an Oxford Notebook, *The Observatory*, Jan. 1902.

THE LIGHT CURVE OF THE NEW STAR IN PERSEUS.

CONTINUED FROM PAGE 38.

Date 1901	Gr. M. T.	Observer.	Comparisons.	Magnitude.		Color
				Obs'r.	Revised	
Apr	h					
13	7.8	Müller	Photometer: σ	4.58	4.62	
		Solá		4.5	4.1	
		Oertel	ν, *I*	4.7		
	8	Valentiner	ν 2 N 3 *I*; N = σ		4.44	
	8.0	Butler		4.3		
	8.7	Robinson	ν, κ, *I*	4.40	4.46	R
	8.8	Wickham	*I*, (72)	4.75	4.85	
	10.0	McClellan	ν, κ, *I*	4.40	4.46	
		Sharp		4.4		
	10.3	Williams	κ 2 N 6 *I*; N 8 (71)	4.35	4.26	
	11.5	Lockyer		4.6		
	12.5	Wendell	Photometer	4.51		
	13.0	Jones		4.70		
	15	Wilson	ν 2 $\kappa = \theta = \iota$ 1 σ 2 ψ 1 N 1 *I* 3 (72) 2 (71) 5 (83)		4.79	
	15.5	Aitken		6.0		
	16.5	Townley	ν 7 *I*; κ 7-8 *I*	4.8	4.74	
14	3.4	Stratanoff		5.41	5.24	
	7.2	Müller A	ϖ	5.5		R
	7.2	Riccò	Photometer: ϵ	5.60	5.37	
	7.5	Harkányi	Photometer	5.60	5.48	
	8.5	Williams	κ 12 N; *I* 5 N; (71) 1 N	5.35	5.55	
	8.6	Raynaud		5.5		
	8.9	Gyllensköld	(72), (82), *I*	5.77		
	8.9	Robinson	(71), (72), (83)	5.50	5.58	
		Solá		6.2	5.4	
		Sharp		5.3		
	9.5	Lockyer		5.4		
	9.7	Wickham	(72)	5.50	5.50	
	10.1	Müller	Photometer: *f*		5.34	
	10.2	Williams	*I* 4 N 2 (71)	5.2	5.25	
	15.0	Stebbins	N 1 (71); (72) 1 N 1 (75)	5.43	5.45	
	16.0	Comstock	(72) 2 N 1 (71)	5.40	5.36	
	16	Aitken		6.1		
	16.0	Hadden	: = (72)	5.4	5.4	
	16.0	Townley	N (71); (72) 2 N	5.4	5.46	
15	7.0	Müller A	σ (85)	6.0		R
	7.1	Sviatsky		5.6		
	7.1	Harkányi	Photometer	5.81	5.70	
	7.4	Luizet		5.6		
	8.0	Lockyer		6.0		
	8.5	Müller	Photometer: *f*	5.67	5.76	
	8.6	Meyermann	(72)	5.40		
	9.0	Robinson	(72), (83)	5.65	5.80	VR
	9.2	Ambronn	*I* 2 N 1 (72); *I* 3 N 1 (72)	5.31	5.27	VR
	9.5	McClellan	(72), *I*	5.70	5.80	
	9.6	Williams	*I* 6 N; (71) 1 N	5.45	5.41	BR
		Sharp		5.6		
	9.7	Müller	Photometer	5.73	6.07	
		Solá		6.4	5.6	
	9.8	Messow	Uncertain	5.4		
	10	Soares		5.58		
	10.1	Williams	(71) 2 N; (72) 1 N	5.55	5.39	
	10.5	Lockyer		5.8		

Date 1901	Gr. M. T.	Observer.	Comparisons.	Magnitude. Obs'r.	Revised.	Color
Apr	h					
15	10.5	Wickham	(72), DM 42°,754	6.40	6.40	
	13.2	Olivier	= (71) and (72); < *l*; much > 83		5.36	
	14.2	Stebbins	(72) 1 N 1 (75); (71) 1 N	5.50	5.51	
	14.5	Comstock	(72) 2 N (72)	5.45	5.35	
	16	Aitken		6.1		
16	6.8	Harkányi	Photometer	5.88	5.77	
	7.2	Müller A	(71)	5.3		R
	7.4	Luizet		5.5		
	7.5	Müller / Kempf	Photometer : (85), (76)	5.80	5.98	RY
	7.5	Höhl		5.5		
	7.5	Valentiner	N 3 < (72); N 2 < (71)		5.76	
	7.6	Archenhold	(71) 2 N	5.70	5.51	
	8.1	Raynaud		6.0		
	8.3	Valentiner	N 1½ < (72); very near = (71)		5.48	
	8.7	Müller / Kempf	Photometer : (85), (76)	5.76	5.94	
	8.8	Archenhold	(71) 1 N	5.63	5.43	
	9.0	Robinson	(72)	5.40	5.40	VR
	9.8	Messow		5.7		
		Oertel	(72), (71). (82)	6.0		
	10.1	Wickham	*l*, (72)	5.15	5.25	R*
	10.2	Robinson	(72), *l*	5.40	5.50	
	11.0	Lockyer		5.5		
	13	Micou	Unchanged since April 10	5.6	5.6	
	13.3	Olivier	*l*, (72), (71), (83)	5.6		
	13.6	Zwack	*l* 5 (72) 3 N 8 (83)		5.67	
	13.7	Daniel		5.77		
	13.9	Hagen	*l* 6 (71) 7 N 3 (72) !		5.37	
	15.8	Hadden	(80)	6.0	6.07	
	16	Aitken		6.0		
17	7.2	Müller A	σ, (85)	4.9		†
	7.3	Riccò	> (71) ; < *l*			
	7.4	Luizet		5.2		
	7.5	Höhl		4.6		
	7.5	Robinson	κ, *l*	4.55	4.67	Y‡
	8.0	Robinson	*l*	4.60	4.79	
	8.0	Valentiner	N = *l*		5.03	
	8.0	Müller	Photometer: *f*, (76)	5.02	5.07	Y
	8.1	Sviatsky		5.1		
	8.5	Lockyer		5.2		
	8.5	Butler		5.1		
	9.0	Robinson	κ, *l*	4.50	4.62	
	9.3	Verschaffel	*l*	5.1		
	9.6	Wickham	(72)	4.80	4.99	RY
	9.8	Williams	*l* 2 N 3 (71)	5.05	5.15	
	10	Soares		5.22		
		Balassny	*l* 0^m.1 N		5.1	Y
		Graff		5.3		Y¶
		Solá		5.1	4.7	
	10.4	Messow		4.4		VR
	12.8	Hagen	ξ 8 N 9 *l*		4.53	
	13.0	Zwack	ξ 11 N 8 *l*		4.62	

* Redder than on the 15th. † Color of σ. ‡ With very red fringes. ¶ Intensely yellow.

Date 1901.	Gr. M. T.	Observer.	Comparisons.	Magnitude. Obs'r.	Revised	Color
Apr.	h					
17	14	Young	N = *l*	5.0	5.03	
	15.1	Whitney	N 2 *l*; N = (67)	4.9	4.88	
	15.5	Aitken		4.4		
	16.0	Hadden	Nearly = κ; vis to naked eye	4.3		
18	6	Balassny		4.2		O
	6.4	Sviatsky		4.5		Y
	7.0	Müller A	*l*	5.1		*
	7.1	Harkányi	Photometer	4.37	4.21	
	7.4	Luizet		4.2		
	7.4	Solá		4.4	4.0	
	7.5	Pola	3 observers	4.2		
	7.8	Meyermann	ν, *l*	4.18		
	7.9	Luizet		4.2		
		Oertel	ν, *l*, κ	4.3		
	8.0	Valentiner	ν 2 N 4 *l*; ψ 2 N = σ		4.44	
	8	Honnorat		4.2		
	8	Balassny		4.1		
	8.0	Küstner	κ 2 N 2 ψ		4.13	
	8.1	Verschaffel	κ, *l*	4.5		
	8.1	Raynaud		4.3		
	8.2	Archenhold	ν 3½ N; almost = ν	4.32	4.1	
	8.2	Ambronn	ν 1 N 2 *l*; ν 1 N 4 (72); ν 1 N 2 *l*	4.34	4.30	
	8.5	Fauth	N = κ; ν 1 N		4.0	
	8.5	Epstein	N almost = κ; > σ > *l*		4.1	
	8.7	Jost	Photometer	4.16		
	8.9	Ambronn		4.34	4.30	
		Sharp		4.1		
	9.0	Lockyer		4.2		
	9.1	Solá		4.7	4.3	
	9.5	Solá		5.0	4.5	
		Messow		4.2		
	10	Epstein	N = κ		4.00	
	10.0	Gyllensköld	κ, ν, *l*	4.06		
	10.2	Müller	Photometer : ν	4.30	4.20	WY
	11.0	Gyllensköld	κ, ν, *l*	4.18		
	11.4	Gyllensköld	κ, ν, *l*	4.12		
	13.5	Brenke	σ = N 4 *l*; N 0.3 *l* to ν	4.6	4.62	
	15.0	Wilson	ν 1 κ 1 θ = ι 2 σ 2 ψ = N 2 *l* 3 (71) = (72) 7 (83)		4.68	
	15.0	Stebbins	(ν 1 N 2 *l*)	4.3	4.30	
	16.0	Townley	κ 5 *l*, ν 4 *l*	4.5	4.44	
19	3.8	Stratanoff		5.10	4.95	
		Balassny	N = *l*	6.0	5.03	
	7.3	Harkányi	Photometer	5.49	5.37	
	7.4	Luizet		5.4		
	7.5	Pola	3 observers	5.5		
		Oertel	*l*, (72), (71)	5.5		
	7.9	Riccò	Photometer : ε	5.04	4.81	
	7.9	Valentiner	N 2 (71); N 1 (72)		5.12	
	8.0	Honnorat		6.0		
	8.0	Lockyer		5.2		
	8	Fauth	*l* 2 N		5.2	R
	8.1	Raynaud		5.5		
		Plassmann		6.0		
		Solá		6.2	5.4	
	8.2	Luizet		5.5		

* Color of σ.

Date 1901.	Gr. M. T.	Observer.	Comparisons.	Magnitude. Obs'r.	Revised.	Color
Apr.	h					
19	8.2	Verschaffel	κ, *l*	6.0		
	8.3	Valentiner	N 3 < *l*		5.51	
	8.4	Küstner	*l* 2 N = (71)		5.35	
	8.4	Wickham	(72), *l*.	5.20	5.30	RY
	8.5	Müller A.	*l*, ω	5.3		*
	8.6	Robinson	*l* (72)	4.95	5.05	VR
	9.8	Williams	*l* 5 N 1 (72); N = (71)	5.35	5.33	VR†
	10.0	McClellan	(72), *l*	5.25	5.35	
		Sharp		5.4		
	12.8	Wendell	Photometer	5.53		
	14.0	Hadden	N = (72)	5.4	5.37	OR
	14.8	Wilson	$\nu = \kappa = \theta$ 1 ι 2 σ 1 ψ 3 *l* 5 (72) = (71) = N 10 (83)		5.36	
	14.8	Stebbins	N (71) (72)	5.4	5.36	
	15.0	Brenke	*l* 4 (72) 4 N	5.7	5.71	
	16	Aitken		5.5		
	16.0	Townley	N (72); (71) 2 N	5.4	5.46	
20	3.7	Stratanoff		5.52	5.35	
	7.3	Riccò	Photometer : ϵ	5.80	5.57	
	8.3	Müller	Photometer : (76)	5.97	6.00	YR
	7.4	Kempf	Photometer : (85)	5.66	6.00	
	7.5	Sola		6.2±	5.6	
	7.5	Luizet		5.7		
		Oertel	*l*, (72), (71)	5.6		
	7.8	Robinson	(79), (72)	6.00	6.10	‡
	7.9	Valentiner	(71) 2 N 3 (80); (72) 3 N		5.70	
	8.0	Honnorat		5.8		
		Plassmann	Between (71) and (83)	6.3	5.8	
	8.2	Archenhold	N = (72)	5.55	5.37	R
	8.3	Valentiner	N 1 (78); N 2 (79)		5·55	
	8.4	Fowler		< 5.5		
	8.4	Küstner	(71) 3 N 1 (72)		5.36	
	8.5	Lockyer		5.9		
	8.5	Ambronn	*l* 1 N 1 (72); *l* 2 N 3 (72); *l* 2 N 3 (72)	5.23	5.18	
	8.5	Butler		5.6		
		Graff		< 6.0		Y
		Epstein	N = (72); > (83); < *l* and (71)		5.37	¶
	8.5	Fauth	*l* 3 N = (72)		5.37	
	8.6	Müller	Photometer : (76)	5.97	5.99	
	8.7	Kempf	Photometer : (85)	5.94	6.28	
	8.8	Müller A	(71), (83)	5.9		
	9.0	Rambaut	(72), 44°648	5.95	5.85	‖
	9.0	Wickham	(72), 44°648	5.73	5.63	
	9.4	Robinson	(83), (72), (71)	5.73	5.88	
	9.5	McClellan	(72), *l*	5.65	5.77	R
	9.6	Archenhold	(72) 2 N	5.70	5.50	
	9.7	Williams	*l* 6 N; (72) 1 N = (71)	5.45	5.39	R§
	9.8	Sharp		5.8		
	10.2	Jost	Photometer	5.27		
	10.7	Sharp		5.6		
	10.8	McClellan	DM 44°648	6.00	6.00	
	14	Brenke	(72) 5 N 5 (83); (71) 5 N 5 (83) *l* 3 (72) 5 N 4 (81) 2 (83)	6.0	5.83	
	14.7	Comstock	(71) 1 N; (72) 2 N	5.50	5.57	

* Color of σ. † Crimson. ‡ Very red. ¶ Color of σ. ‖ (44°648) is orange. § Crimson.

Date 1901.	Gr. M. T.	Observer.	Comparisons.	Magnitude. Obs'r.	Revised.	Color
Apr.	h					
20		Stebbins	(71) 1 N 1 (75); (72) 3 N	5.53	5.54	
	15.0	Wilson	$\nu = \kappa = \iota$ 1 σ 2 ψ 3 *l* 5 (72) = (71) 1 N 9 (83)		5.47	
	16.0	Townley	(72) 2 N	5.6	5.57	
	16	Aitken		6.2		
21	3.9	Stratanoff		5.49	5.32	
	7.5	Höhl		5.9		
	7.7	Riccò	Photometer : ϵ	5.83	5.60	
		Oertel	(71)	6.2		
	7.7	Solá		6.3	5.4	
	7.7	Harkányi	Photometer	6.10	6.00	
	7.8	Muller / Kempf	Photometer : (85)	6.01	6.35	R
	8	Schwab	N = (72)		5.27	
	8.1	Raynaud		< 6.0		
	8.2	Valentiner	N 2 (72)		5.05	
	8.2	Epstein	(71) > (72) > N > (83)			
	8.4	Ambronn	*l* 6 N 1 (72) ; N = (72)	5.38	5.35	
	8.5	Giovannozzi		5.4		
		Plassmann		6.3	5.8	
	8.7	Muller A.	(82)	6.0		*
	8.8	Williams	(71) 3 N; (72) 2 N = (83)	5.9	6.07	
		Sharp		5 7		
	9.0	Lockyer		6.1		
	9.0	Butler		6.0		
	9.0	Wickham	(72) DM 44°648	6.15	6.15	
	9.0	Kempf	Photometer : (85)	6.09	6.43	
	9	Köhl	N = (72)	5.41	5.37	
	9.4	Robinson	(83), (71), (72)	5.87	5.95	
	9.7	Kustner	(71), 3 N 3 (79); (72) 1 N 1 (78) (71) 3 N 4 (83)		5.59	
	9.7	Jost	Photometer	5.04		
		Messou		5.7		
		Graff		5.5		R
	10.0	Williams	(71) 2 N; (72) 2 N 2 (83)	5.8	5.85	R
	14.0	Hadden	N 1 (79)	5.6		R
	14.5	Hadden	N 1 (79)	5.6		DO
	16.0	Townley	N (72); (71) 2 (83); (71) 2-3 N	5.5	5.51	
	16	Aitken		5.6		
22	3.6	Stratanoff		5.45	5.28	
	7.4	Muller / Kempf	Photometer ; (85)	5.74	6.08	RY
	7.5	Höhl		5.8		
		Oertel	*l*, (72), (71)	5.7		
	8	Schwab	N = > (72)		5.37	
	8.0	Honnorat		6.0		
	8.4	Wickham	(72)	5.60	5.60	R
	8.5	Kustner	(71), 3 N 3 (78); N = (72)		5.49	
	8.7	Robinson	(72), (79)	5.55	5.45	R†
	8.8	Sharp		5.5		
	9.0	Epstein	N = (72) < (71)		5.37	
	9.0	Lockyer		5.7		
		Messow		5.6		
	9.0	Ambronn	*l* 1 N 1 (72); N = (71)	5.25	5.25	
	9.0	Robinson	(72) (79) (83)	5.50	5.53	
	9.1	Wickham	(72)	5.20	5.20	

* Color of σ. † Not so red as on the 20th.

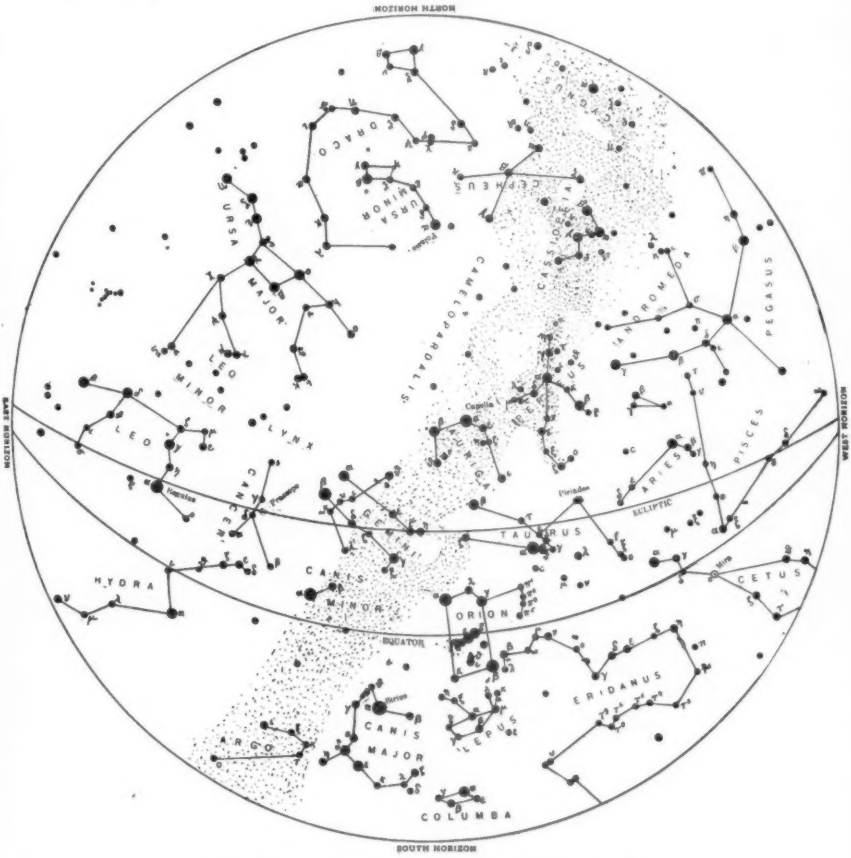
Date 1901.	Gr. M. T.	Observer.	Comparisons.	Magnitude.		Color
				Obs'r.	Revised	
Apr.	h					
22	9.2	Williams	(71) 6 N 2 (83)	6.15	6.10	
	9.2	Giovannozzi		5.4		
	9.5	Müller / Kempf	Photometer : (85)	5.83	6.17	
	9.5	Fauth	(72) 1 N; > (71)		5.36	R
	9.7	Williams	(71) 1 N 3 (83)	5.85	5.60	
	10.0	Plassmann		6.3	5.8	
	10.2	Sharp		5.2		
	10.3	Jost	Photometer	5.16		
	10.5	Williams	(71) = N 1 (72)	5.35	5.35	R
	10.6	Müller / Kempf	Photometer : (85)	5.68	6.02	
	15.2	Wilson	ν 1 $\kappa = \iota$ 1 σ 2 ψ 5 N 1 *l* 5 (72) = (71) 10 (83)		4.86	
	16.0	Stebbins	N (ν*l*)	4.5	4.58	
	16.3	Townley	N 1 *l*; κ 8 *l*	5.0	4.88	
	16.5	Aitken		4.7		
23	3.4	Stratanoff		4.66	4.53	
	7.4	Riccò	Photometer : ϵ	4.58	4.35	
	7.5	Höhl		4.6		
	7.6	Müller / Kempf	Photometer : σ, κ	4.26	4.28	
	7.8	Giovannozzi		4.3		
		Balassny	N = *k*	5.0	5.08	
		Messow		4.2		WY
		Graff		4.25		YW*
		Luizet		4.4		
		Oertel	ν, κ, *l*	4.5		
	8	Schwab	ν 2 N = > κ		3.99	
	8.2	Meyermann	ν, *l*	4.47		
	8.5	Plassmann		5.4		
	8.5	Collette	= κ	4.4	4.00	
	8.6	Williams	κ 1 N; ν 5 N	4.3	4.02	W†
	8.7	Plassmann		4.7		
	8.7	Ambronn	ν 1 N 2 *l*; κ 1 N 2 *l*; κ 1 N 3 (71)	4.36	4.33	
	8.8	Williams	κ 2 N; ν 6 N 10 *l*	4.2	4.28	
	8.9	Plassmann		4.4		
	8.9	Williams	κ 1 N; ν 5 N 8 *l*	4.2	4.26	
	9	Köhl		4		
	9	Fauth	κ 2 N 2 *l*		4.52	
	9	Bosc	> *l* < ν > σ and ψ	4.6		R
	9.1	Williams	κ 1 N; ν 4 N	4.2	4.02	
	9.2	Giovannozzi		4.1		
	9.3	Wickham	ν, κ, σ, ψ, *l*	4.48	4.54	DO
	9.3	Robinson	κ, ν, *l*	4.27	4.33	
	9.4	Kustner	ν 3 N 2 σ		4.31	
	9.5	Müller / Kempf	Photometer : σ, κ	4.21	4.23	
	9.6	Williams	κ 1 N; ν 4 N 8 *l*	4.15	4.22	
	9.6	McClellan	*l*, κ, ν	4.27	4.33	‡
	10	Epstein	: = κ and σ; > *l* and (71)		4.28	
	10.1	Williams	κ 1 N; ν 6 N	4.3	4.01	
	10.5	Williams	κ 1 N; ν 4 N	4.2	4.02	
	11.1	Plassmann		4.4		
	14.2	Comstock	κ 2 N 1 ψ	4.20	4.17	

* Almost white. † White or slightly yellowish. ‡ Less red.

PLANET NOTES FOR FEBRUARY.

H. C. WILSON.

Mercury is now evening star seen toward the southwest after sunset, about 7° south from Venus. Mercury will be at greatest elongation, east from the Sun 18° 17′, on the morning of Feb. 3. During February it makes a great loop in its path, as shown on the chart in the January number of POPULAR ASTRONOMY, passing between the Earth and the Sun on Feb. 18. After that time Mercury will be morning star.



THE CONSTELLATIONS AT 9 P. M. FEBRUARY 1902.

Venus has been so brilliant during the past month that one's shadow in the light of the planet has been easily noticed. During the first half of February the planet rapidly approaches the line joining the Earth and Sun, and her dark side

will be turned toward us, the crescent phase growing thinner and thinner until Feb. 12, when inferior conjunction will occur. On the 12th and 13th it may be possible, by taking the proper precautions, for the observer to see the twilight ring all the way around the dark disc of Venus. It is necessary, for this purpose, to use a telescope of considerable power and to stop down the aperture of the eyepiece to a pinhole. The observation must be made near noon, when the planet is at its greatest altitude. At this time the planet will be about 8° north of the Sun.

In the list of phenomena on p. 510 of the *American Ephemeris* the time of inferior conjunction of Venus is given as Feb. 14 at 6 P. M. Washington mean time, but this is evidently an error, for according to the ephemerides of the Sun and Venus on pp. 400 and 420 the two objects differ in right ascension by 11^m at that time.

Mars is on the farther side of the Sun and therefore invisible during February.

Jupiter and *Saturn* are also invisible on the farther side of the Sun having passed inferior conjunction during January.

Uranus is morning star in Scorpii but will not be in position for observation until the summer.

Neptune is now in good position for observation, and is to be found in the evening in the constellation Gemini about 3° west from the star η. One will need a telescope of three or four inches aperture in order to easily identify this planet, and with this it will be necessary to make careful charts, on two or three nights, of the small stars in the region named. When once the grouping of the small stars becomes familiar, the planet may be followed by its movement from day to day.

A considerable group of sunspots was visible near the center of the Sun's disc on Jan. 8. It had diminished very much on the 14th and had disappeared by rotation on the 16th. A quite brilliant auroral arch 5° high, extending in azimuth from N 30° W to N 45° E, was observed at Northfield on the evening of Jan. 15.

The Moon.

	Phases.	Rises. (Central Standard Time at Northfield Local Time 13m less.)	Sets.
		h m	h m
Feb. 8	New Moon	7 04 A. M.	6 06 P. M.
14-15	First Quarter	10 17 "	1 02 A. M.
21-22	Full Moon	5 18 P. M.	6 44 "
Mar. 1	Last Quarter	12 36 A. M.	10 22 "

Occultations Visible at Washington.

Date. 1901.	Star's Name.	Magnitude.	IMMERSION. Washington M.T.	IMMERSION. Angle f'm N pt.	EMERSION. Washington M. T.	EMERSION. Angle f'm N pt.	Duration.
			h m	°	h	°	h m
Feb. 1	ν Scorpii	4.2	16 12	49	16 58	341	0 46
15	B.A.C. 1240	5.7	4 24	74	5 44	259	1 20
18	W.B.(2)VI,1630	5.9	4 45	68	5 47	298	1 02
18	λ Geminorum	3.6	14 03	176	14 23	215	0 20
20	60 Cancri	5.7	4 41	122	5 35	261	0 54
20	κ Cancri	5.1	11 31	133	12 47	277	1 16
24	28 Virginis	7.0	18 45	80	19 38	326	0 53
25	α Virginis	1.2	15 26	150	16 38	260	1 12

COMET AND ASTEROID NOTES.

Definitive Orbit Elements of Comet 1891 I.—In *A. N.* 3748 Mr. C. J. Merfield of Sydney, Australia, gives the following definitive elements of the orbit of Comet 1899 I, computed from 17 normal places from Mar. 6 to Aug. 9, 1899, depending upon all the available published observations.

EPOCH OF OSCULATION 1899, MARCH 12.

$T = 1899$ April 12.978010 Greenwich M. T.

$\omega = 8° 41' 46''.48$
$\Omega = 24 59 59 .93$ } 1900.0
$i = 146 15 30 .29$

$\log q = 9.5139795$
$\log e = 0.0001521$
$\epsilon = 1.00035029$

Elements of Asteroid (455) Bruchsalia.—In *A. N.* 3750 Dr. Berberich gives the following new elements of asteroid (455):

EPOCH 1900 MAY 25.5 BERLIN M. T.

$M = 285° 56' 04''.6$
$\omega = 269 12 53 .1$
$\Omega = 77 12 01 .7$ } 1900.0
$i = 12 01 53 .0$
$\phi = 16 55 31 .5$
$\mu = 817''.864$
$\log a = 0.424884$

Elements of Asteroids (465), (468), (469), (471) and (472).—In *A. N.* 3756 Mr. J. Bauschinger gives the following elements of recently discovered asteroids. Each set of elements depends upon only three or four single observations and so must only be regarded as provisional:

Asteroid	(465) 1901 FW	(468) 1901 FZ	(469) 1901 GB
Epoch	1901 Jan. 23.5	1901 Feb. 22.5	1901 Mar. 26.5 Berlin M. T.
M	294° 45′ 01″.5	118° 51′ 21″.4	336° 54′ 03″.9
ω	271 59 03 .2	330 58 25 .9	84 55 36 .1
Ω	305 24 23 .1	22 23 16 .6	88 47 38 .2 } 1901.0
i	4 35 53 .2	0 29 41 .6	12 49 06 .9
ϕ	13 55 45 .9	11 47 14 .8	8 23 55 .0
μ	621″.181	637″.306	583″.731
$\log a$	0.504526	0.497106	0.522534

Asteroid	(471) 1901 GN	(472) 1901 GP
Epoch	1901 May 18.5	1901 Aug. 9.5 Berlin M. T.
M	251° 39′ 15″.6	255° 42′ 27″.4
ω	312 49 54 .8	288 20 40 .3
Ω	84 09 45 .5	127 04 30 .2
i	17 52 41 .8	15 37 46 .1
ϕ	19 56 12 .3	5 54 20 .5
μ	691″.282	871″.928
$\log a$	0.473568	0.406351

Elements of Asteroid (466) 1901 FX.—In *A. N.* 3751 Mr Hans Osten, of Bremen, gives the following elements derived from 5 observations on the dates Jan. 17, 19, 22, Feb. 20 and 25, 1901:

EPOCH 1901 JAN. 17.5 BERLIN M. T.

$M = 298° 03' 54''.4$
$\omega = 261 47 28 .2$
$\Omega = 291 33 22 .9$ } 1901.0
$i = 18 51 05 .2$

$\phi = 6° 25' 53''.9$
$\mu = 569''.60$
$\log a = 0.529625$

New Asteroids.—Seven new asteroids were photographed at Heidelberg in November. Their positions were:

	Discoverers.	Heidelberg M. T.	R. A.	Decl.	Mag.
		h m	h m	° ′	
1901 HC	Wolf-Kopff	Nov. 2 9 23.2	2 07.7	+ 3 42	13.0
HD	"	5 12 09.5	3 01.0	+ 1 06	13.0
HE	Kopff	3 11 13.4	2 28.6	+ 8 34	13.5
HF	Wolf	6 12 56.5	4 59.6	+13 17	11.5
HG	Wolf-Carnera	6 12 56.5	5 08.3	+18 14	11
HH	Wolf	12 9 48.4	2 31.7	+ 5 41	11.0
HJ	Carnera	12 8 41.1	3 14.9	+ 1 27	11.3
HK	Carnera	6 14 59.8	5 07.3	+20 11	...

HG turns out to be (455) Bruchsalia. HK was supposed by Wolf to be (367) Amicitia, but Dr. Kreutz considers it to be new.

Elements of Asteroid (470) Kilia.—The following elements given in *Astr. Nach.* No. 3757 were computed by Mr. J. Möller, of Kiel, Germany, from observations April 23, May 9 and 14:

EPOCH 1901, MAY 14.5 BERLIN M. T.

$M = 61° 45' 29''.9$
$\omega = 290\ 43\ 13\ .6$
$\Omega = 182\ 55\ 59\ .8$ 1901.0
$i = 10\ 34\ 35\ .6$

$\phi = 20° 09' 47''.6$
$\mu = 789''.0880$
$\log a = 0.435247$

Elements of Asteroid 1900, GA.—This asteroid was discovered June 28, 1900, by the late Director James E. Keeler, of Lick Observatory. The following elements were calculated from three observations by Professor Armin O. Leuschner and Miss Adelaide M. Hobe of the University of California. The magnitude of the asteroid upon the photographs taken with the 36-inch Crossley reflector was estimated at between 15 and 16.5 Adopting the mean 15.75, the magnitude m_0 at the mean distance of the asteroid would be 18.0. It is therefore the faintest planet so far observed. Its magnitude at the present opposition is calculated to be 19.5, so that it is not likely to be observed. Its position Feb. 2 is, R. A. $6^h\ 28^m.7$; Decl. + 25° 15′.

EPOCH 1900 JUNE 30.817165 GR. M. T.

$M = 350° 22' 16''.9$
$\phi = 196\ 08\ 05\ .5$
$\Omega = 97\ 36\ 55\ .6$ 1900.0
$i = 6\ 56\ 23\ .1$

$\phi = 16° 22' 55''.0$
$\mu = 1122''.174$
$a = 2.154257$
Period = 1154.901 days.

Asteroid 1901 GV.—In *Astr. Nach.* No. 3752 elements of this planet are given by Manoel Soares de Mello e Simas, of Ponta Delgada, Azores. Professor Bauschinger calls attention to the fact these elements are so near those of (202) Chryseis that the two are probably identical.

VARIABLE STARS.

New Variable Star 96,1901 Cygni.—This was discovered by Mr. A. Stanley Williams from a number of photographs. It is BD + 29°4231, R. A. $20^h\ 49^m\ 02^s.1$; Decl. + 29° 51′.8 (1855). The period and range of variation are uncertain at present, but the magnitude at maximum is probably 9.0, visual, and 9.7, photographic, and below 12.0 at minimum. From photographs the magnitudes of the star were as follows: 1901 Sept. 21, 10.8; Oct. 7, 10.3; Oct. 14, 9.8; Nov. 1, 9.9; Nov. 3, 10.5. The variable is absent altogether from plates taken Oct. 6 and 9, 1899, and Oct. 26, 27 and Nov. 15, 1900, and must on those dates have been fainter than 12^m.

Minima of Variable Stars of the Algol Type.

[Greenwich Mean Time beginning with midnight. The hours greater than 12 are those of the afternoon. To obtain Eastern Standard time subtract 5 hours; for Central Standard subtract 6 hours.]

U Cephei.

d	h
Feb. 2	4
4	16
7	4
9	16
12	3
14	15
17	3
19	15
22	3
24	15
27	2

Algol.

Feb. 3	16
6	12
9	9
12	6
15	3
18	0
20	21
23	17
26	14

λ Tauri.

Feb. 2	10
6	9
10	8
14	7
18	5
22	4
26	3

R Canis Maj.

Feb. 1	7
2	10
3	14
4	17
5	20
6	23
8	3
9	6
10	9
11	12
12	16
13	19
14	22
16	1
17	5
18	8
19	11
20	15
21	18

R Can. Maj. Cont.

d	h
Feb. 22	21
24	0
25	4
26	7
27	10
28	13

S Cancri.

Feb. 6	14
16	2
25	14

S Antliæ.

Period $7^h\ 46^m.8$

Feb. 1	4
2	3
3	3
4	2
5	1
6	1
7	0
7	23
8	23
9	22
10	21
11	21
12	20
13	19
14	19
15	18
16	17
17	17
18	16
19	15
20	15
21	14
22	13
23	13
24	12
25	11
26	11
27	10
28	10

δ Libræ.

Feb. 1	9
3	17
6	0
8	8
10	16
13	0
15	8

δ Libræ Cont.

d	h
Feb. 17	16
20	0
22	7
24	15
26	23

U Coronæ.

Feb. 4	4
7	15
11	2
14	12
17	23
21	10
24	21
28	8

U Ophiuchi.

Feb. 1	4
2	0
2	20
3	16
4	12
5	8
6	4
7	1
7	21
8	17
9	13
10	9
11	5
12	1
12	21
13	18
14	14
15	10
16	6
17	2
17	22
18	18
19	14
20	11
21	7
22	3
22	23
23	19
24	15
25	11
26	8
27	4
28	0
28	20

Z Herculis.

Feb. 2	22
4	23
6	22
8	23

Z Herculis Con.

d	h
Feb. 10	22
12	23
14	22
16	23
18	21
20	23
22	21
24	22
26	21
28	22

V^3 Cygni.

Feb. 5	6
11	7
17	7
23	7

U^3 Cygni.

Feb. 3	10
8	0
12	14
17	4
21	17
26	7

W Delphini.

Feb. 4	15
9	10
14	6
19	1
23	20
28	16

Y Cygni.

Feb. 1	7
2	15
4	7
5	14
7	6
8	14
10	6
11	14
13	6
14	14
16	6
17	14
19	6
20	14
22	6
23	14
25	6
26	14
28	6

Variable Stars of Short Period not of the Algol Type.

	Minimum.		Maximum.			Minimum.		Maximum.	
		h		h			h		h
U Sagittarii	Feb. 1	13	Feb. 4	12	S Sagittae	Feb. 15	2	Feb. 18	12
T Vulpeculæ	2	4	3	14	U Geminorum	15	5	17	22
ζ Geminorum	3	2	8	2	T Vulpeculae	15	12	16	22
β Lyræ	3	4	6	13	Y Sagittarii	15	20	17	15
δ Cephei	3	6	4	21	β Lyrae	16	2	19	11
T Monocerotis	4	0	11	22	δ Cephei	19	9	21	0
Y Sagittarii	4	7	6	2	T Vulpeculae	19	22	21	8
T Vulpeculæ	6	15	8	0	η Aquilae	20	11	22	17
U Aquilæ	6	16	8	20	U Aquilae	20	17	22	22
S Sagittæ	6	17	10	3	Y Sagittarii	21	14	23	9
W Sagittarii	7	4	10	4	U Sagittarii	21	19	24	18
W Geminorum	7	11	10	2	X Sagittarii	21	21	24	18
X Cygni	7	11	14	6	W Sagittarii	22	8	25	8
X Sagittarii	7	20	10	17	β Lyrae	22	13	25	15
U Sagittarii	8	7	10	2	W Geminorum	22	23	25	15
δ Cephei	8	15	10	6	ζ Geminorum	23	9	28	9
β Lyræ	9	15	12	7	S Sagittae	23	11	26	21
Y Sagittarii	10	1	11	20	X Cygni	23	20	Mar. 2	15
T Vulpeculæ	11	1	12	10	T Vulpeculae	24	9	Feb. 25	18
W Virginis	11	2	19	6	δ Cephei	24	18	26	9
Y Ophiuchi	12	15	18	20	Y Sagittarii	27	9	Mar. 1	4
ζ Geminorum	13	6	18	6	η Aquilae	27	15	1	21
η Aquilæ	13	7	15	13	U Aquilae	27	18	1	22
U Aquilæ	13	17	15	22	W Virginis	28	8	8	12
δ Cephei	14	0	15	15	U Sagittarii	28	13	3	12
W Sagittarii	14	18	17	18	T Vulpeculae	28	19	2	4
X Sagittarii	14	21	17	18	X Sagittarii	28	21	3	18
U Sagittarii	15	1	18	0					

Maxima of U Pegasi.

[Period $4^h\ 29^m\ 8^s$; the minimum takes place $2^h\ 15^m$ after the maximum.]

	d	h		d	h		d	h		d	h
Feb.	1	20	Feb.	8	23	Feb.	15	22	Feb.	22	20
	2	23		9	22		16	20		23	23
	3	22		10	20		17	23		24	21
	4	20		11	23		18	21		25	20
	5	23		12	22		19	20		26	23
	6	22		13	20		20	23		27	21
	7	20		14	23		21	21		28	20

Maxima and Minima of Long Period Variables.

[Computed from Chandler's "Third Catalogue" by Misses Ida I. Watson and Helen M. Swartz of Vassar College Observatory.]

Maxima.			Maxima.			Minima.		
Date Feb.	No.	Star.	Date Feb.	No.	Star.	Date Feb.	No	Star.
3	5593	W Libræ	16	5190	R Camelopar.	1	7192	Z Cygni
3	6921	S Sagittarii	17	5770	R Herculis	3	806	*o* Ceti
4	7252	W Capricorni	20	5504	S Coronæ	4	2735	U Canis Min.
7	3825	R Ursæ Maj.	22	5955	R Draconis	15	4847	S Virginis
7	4948	CanumVenat.	23	5704	RR Libræ	16	4492	Y Virginis
10	1623	T Camelopar.	24:	678	U Persei	16:	6943	T Sagittæ
13:	7155	RR Aquilæ	26:	3170	S Hydræ	19	906	R Trianguli
13	7560	R Vulpeculæ	26	4521	R Virginis	20	8600	R Cassiopeæ
16	5157	S Bootis	27	7609	T Cephei	21	2528	R Geminorum
						25	5430	T Libræ

Nova Persei.—In *Astr. Nach.* 3755 Professor W. Ceraski, of Moscow, calls attention to a faint star, found by M. Blajko upon a photographic plate taken at Moscow Jan. 30, 1899, which occupies a position very close to that of the nova, but which is now invisible with a 15-inch telescope. Measures of the plate give for its position with reference to the present place of the nova: $\Delta\alpha = +0^s.31$ and $\Delta\delta = -7''$. On the photograph the star is of about the 12th magnitude. Dr. Kreutz suggests that this star may possibly be identical with No. 69 of Hagen's Second Chart and Catalogue.

In another part of this number we give a translation of a very interesting and we think very important article by Professor Kapteyn, of Groningen. The explanation which he gives, of the apparent movements of the nebulosity about the nova, does away with the necessity of assuming such incredible velocities of ponderable masses as have hitherto seemed required by the observed phenomena, and makes the movement due to the simple wave motion of light, with which we are more familiar. The great difficulty in the way of the acceptance of this theory is the question, whether it is possible for the reflected light from such a source to be sufficiently intense to produce even the feeble effect which is evident in the photographs. It is evident according to this explanation that the light which reached us Sept. 20 from the outer knots of nebulosity, if it was simply the reflection of the outburst of light which reached us Feb. 23, must have been travelling out from the star for seven months before being reflected, and must therefore have suffered an enormous diminution of intensity, from being spread over the surface of a sphere whose radius was $209 \times 24 \times 60 \times 60 \times 186{,}000 = 3{,}359{,}000{,}000{,}000$ miles. If we should assume the radius of the emitting surface of the nova at its brightest to be one million miles, the diminution of intensity area for area at the surface reached in seven months would be as the square o 3,359,000 to 1, or approximately as 11,000,000,000,000 to 1, even if all the light should be reflected. It is a pretty hard proposition to believe that light one eleven-trillionth as intense as that of the nova could produce any effect upon the sensitive plate.

With the 8-inch photographic refractor at Goodsell Observatory a 12th magnitude star will produce a perceptible stain on the most sensitive film in 1 minute. I presume that with Mr. Ritchey's 20-inch reflector the same effect would be produced in less than one-third the time, perhaps in one-fifth of the time or 12 seconds. Mr. Ritchey says that the brightest parts of the Nova Persei nebula could be photographed in two hours but I think we may be safe in saying that the stains produced in the seven-hour exposure were not denser than those of twelfth magnitude stars in 12 seconds. If brightness were inversely proportional to the length of exposure required to produce a perceptible stain on the sensitive film, according to the above assumptions the brightest nebulous patches near the nova would be about 1/2000 as bright as a twelfth magnitude star. This I think is understating their brightness very much, since the length of exposure required varies more nearly as the inverse square of the brightness.

The magnitude of the new star at its maximum on Feb. 23 was almost exactly 0.0, hence it was then about 62,500 times as bright as a twelfth magnitude star. This would make it only 125,000,000 times as bright as the outer nebulosity, leaving a wide gap between one hundred and twenty-five million and the ten trillion required to account for the luminosity of the nebula by reflected light. Whether this gap can be bridged by rigid mauhematics and more correct assumptions remains to be seen.

In *Astr. Nach.* No. 3759 Mr. H. Seeliger supports the theory of Professor Kapteyn, saying that he had come to the same conclusion in the course of his

studies and that he was about to send a paper on the subject to the *Nachrichten* when he received the copy containing Professor Kapteyn's note. He claims in his investigations of the stellar universe to have shown that dust-like matter at a distance of several seconds of arc from a faint star may shine as a faintly luminous nebula, and that the surface-brightness of such a nebula, having a parallax of 0″.01 and illuminated by a star of the 10.4 magnitude at a distance of 10″, may under certain circumstances approximate one 10-millionth of the average surface-brightness of the full Moon. Assuming the nova at maximum to have been at least 12,000 times as bright as a 10.4 magnitude star, he extends the circle, within which reflected light might be visible, to about 1100″ in the case of that star.

Mr. Seeliger considers that the explanation given by Kapteyn is quite consistent with his theory of variable stars, viz., that they are due to dark stars entering cosmical clouds of dark or faintly luminous matter, and that the recent phenomena of Nova Persei are therefore highly confirmatory of his theory.

GENERAL NOTES.

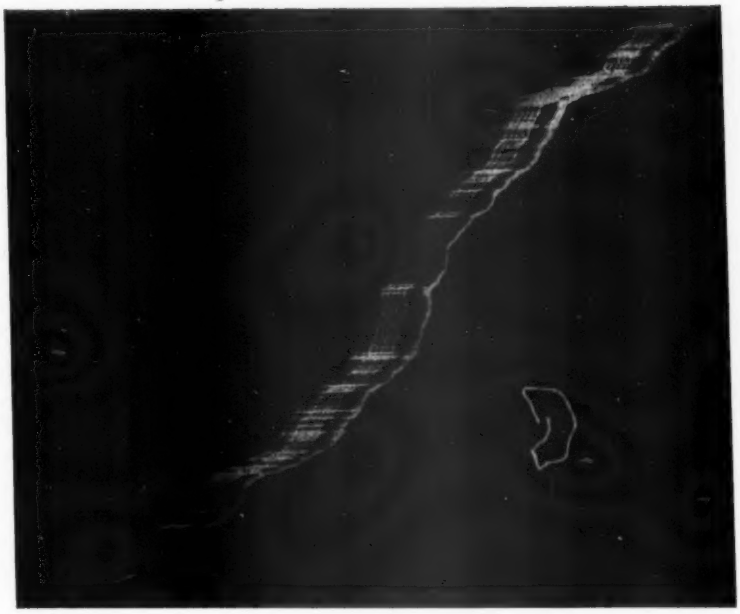
Spectrum of Lightning.—Photographs of the spectrum of lightning were obtained on July 18 and 21, 1901, by Mr. J. H. Freese, under the direction of Edward S. King. The 8-inch Draper telescope was used with an objective prism. The telescope was directed to the portion of the sky in which the lightning was particularly bright, and when the observer thought that he had obtained an image, the plate was changed. Even then many of the plates were badly fogged. A number of photographs were taken in this way, and showed the curious fact that the spectrum of lightning is not always the same. One flash on July 18 showed three bright bands while another taken on the same evening showed ten bright lines, and closely resembled one taken on July 21. The latter is shown in Figure 1. To increase the contrast of the original negative a double contact print was made from slow plates, and is reproduced in the figure on the original scale. The brighter portion of a second flash, clearly seen in the original negative, also appears in the print. Measures, each consisting of three sittings were made of three portions of the principal spectrum, and the means of the results are given in Table I. The original negative was an isochromatic plate. The successive columns give the hydrogen lines with which certain of the lines are assumed to be identical, the mean wave-length and intensity of the lines in the spectrum of lightning, and the wave-length and intensity of the principal lines in the spectrum of Nova Persei, No. 2, on March 23, 1901.

TABLE I.

SPECTRA OF LIGHTNING AND NOVA PERSEI.

Hyd.	W. L.	Int.	W. L.	Int.	Hyd.	W. L.	Int.	W. L.	Int.
Hη	.....	....	3836	4	Hγ	4341	5	4341	10
H[	3881	10	3889	5		4441	?	4468	4
Hε	3956	2	3970	7		4519	1	4573	3
	3998	3				4643	8	1446	6
	4046	2	4030	2		4754	1	.....	....
Hδ	4102	8	4102	8	Hβ	4861	5	4862	10
	4147	4	4149	1		4940	?	4925	1
	4187	?	.....	..		5022	2	5015	3
	4222	5	R	2		5173	1	5171	3
	4263	1	.....	..		5595	30	R	20

PLATE VIII.



THE SPECTRUM OF LIGHTNING FLASH.

The first line in the spectrum of lightning is a broad, bright band, extending from wave-length 3830 to 3930, and is perhaps identical with the nebular line 3875. The line 4222 appears as a broad band in the Nova. The last band is very broad or perhaps a continuous spectrum extending in both objects from about wave-length 5300 to 6000. The lines in the two spectra appear to resemble each other closely both in position and intensity. On September 15, 1901, a photograph was obtained with the 11-inch Draper telescope, showing nearly thirty bright lines. Some of these show a curious doubling, the separation varying in different portions of the flash. Apparently, this is due to another flash, in whose spectrum only a portion of the lines appear. EDWARD C. PICKERING.

HARVARD COLLEGE OBSERVATORY CIRCULAR No. 62.
November 16, 1901.

The Leonids of 1901.—Notwithstanding the disappointing results of the watches for meteors from Leo during the past three years, arrangements were made here this year so that anything of interest relating to the Leonids might be noted. With the assistance of students in astronomy, a program of observations was carried out which covered the nights of the 14th and 15th of November, with three persons on duty during the entire period from midnight to daylight. During the two preceding nights, counts of an hour each were made, in order to learn something of the distribution of the meteors at some distance from the center of the stream.

The weather was all that could be desired, the air calm, temperature not below 30°, and the sky splendidly clear, except during a short time about midnight on the 14th, quite unlike its appearance on corresponding nights of 1899 and 1900, when dense clouds completely and persistently obscured the heavens.

During the observations the attention was fixed chiefly on a circle of 60° radius surrounding the "sickle," although a few meteors were also counted outside this area. The number of meteors seen is as follows:

90th Mer. M. T.		Leonids.	Total.	90th Mer. M. T.		Leonids.	Total.
	h h				h h		
Nov. 12	14:00—15:00	17	17	Nov. 14	16:00—16:15	35	
13	14:45—15:50	21	21		16:15—16:30	18	
14	12:30—12:50	10			16:30—16:45	45	
	13:19—13:30	4			16:45—17:00	42	
	13:30—13:45	10			17:00—17:15	54	
	13:45—14:00	13			17:15—17:30	40	
	14:00—14:15	18			17:30—16:37½	20	467
	14:15—14:30	12		15	13:04—13:45	13	
	14:30—14:45	21			13:45—14:15	12	
	14:45—15:00	21			14:15—14:47	18	
	15:00—15:15	20			14:47—15:26	16	
	15:15—15:30	30			15:26—15:55	20	
	15:30—15:45	29			15:55—16:25	12	91
	15:45—16:00	25					

The hourly numbers for the 14th are:

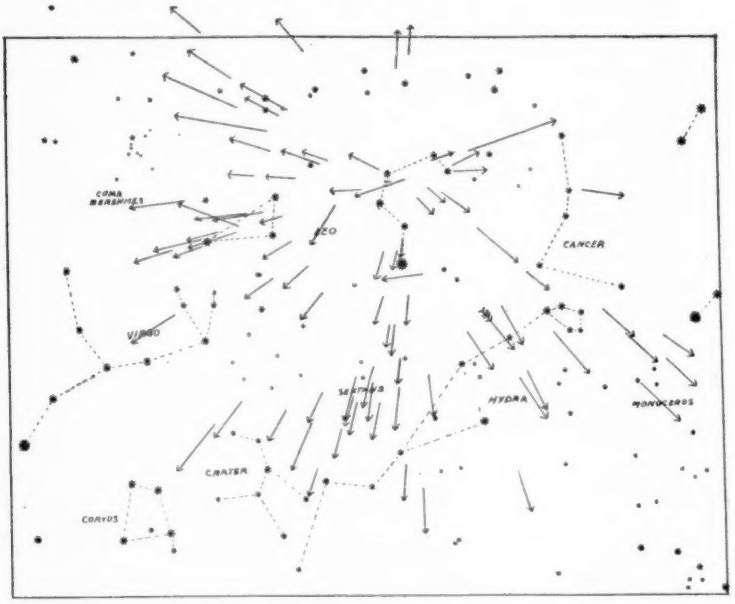
h h		h h	
13:30—14:30	53	15:30—16:30	107
14:30—15:30	92	16:30—17:30	181

The maximum of the shower as observed here evidently occurred during the last of these intervals, and by reference to the original notes it is found that during the five minutes 17:00—17:05 more meteors were recorded than during any other equal interval. The rate being 288 an hour. Subsequent diminution in

frequency was probably due to increasing daylight, since meteors were observed at practically the same rate fully two hours later at the Mount Lowe Observatory. (POPULAR ASTRONOMY No. 91).

Among the features of the display the following were noted, The meteors were white and bluish-white in color, the brighter ones often brilliantly blue, the trails straight and persistent and of blue and greenish tints. The average time of flight was estimated at one-third to one-half seconds, and the average length of trail at about 5°-6°.

Very few faint meteors were seen, although the sky was cloudless and the Moon absent. Nearly all the meteors were observed inside a circle of 40° radius, with center at the radiant. Few appeared in the immediate vicinity of the radiant. The large majority of the meteors were seen south and southwest of the radiant. and relatively few on the opposite side.



THE LEONIDS OF 1901, UNIVERSITY OF ILLINOIS, URBANA.

The estimated magnitudes of 585 meteors are distributed as follows, magnitude — 3 designating all those brighter than Venus:

Magn.	−3	−2	−1	0	1	2	3	4	5.6
Number	7	9	21	53	108	130	93	93	71

Of second magnitude or brighter there are 328 meteors, and 257 fainter than second magnitude.

The accompanying chart contains 82 trails. All were charted on the night of the 14th-15th, 19 of them at about 14^h, and the rest between $16^h\ 30^m$ and $17^h\ 30^m$. For the first set a chart to one-third the DM. scale was used, and for the second a copy from Schurig's Atlas.

A solution for the radiant from the two sets of trails gives,

		Radiant 1901.0			Radiant 1901.0
Set I	R. A.	$150°.9 \pm 0°.27$	Set II	R. A.	$149°.2 \pm 0°.15$
	Decl.	$22\ .9 \pm 0\ .20$		Decl.	$24\ .1 \pm 0\ .15$

In the solution, trails nearly parallel were combined into single means, giving 7 observation equations from the first set and 14 from the second.

Seventy per cent. of the meteors of Set II. passed within one degree of the radiant given above. Accordingly thirty per cent. would pass outside a circle of 2° diameter described about the radiant. That the latter is not a point seemed quite obvious during the progress of the shower, for meteors appeared not infrequently, whose trails, produced backwards, would miss the general radiant point of the majority by an easily perceptible amount.

Regarding the density of meteoric matter in space, a frequency of 300 an hour, when all the meteors appear within 50° of the radiant, would cause about one million meteors per hour to enter the atmosphere of the Earth's advancing hemisphere, and corresponds to one meteor in each cube of space measuring 200 miles on the edge. In 1866 the edge of a similar cube was a little less than 100 miles, and in 1833, on the basis of Olmsted's hourly frequency of 30,000, about 40 miles.

Of the many brilliant meteors seen, by far the brightest appeared Nov. 14th at $14^h\ 54^m\ 20^s$. It lighted up the entire sky, was intensely blue in color, and left a broad trail, persisting for sixteen minutes. During this time it drifted slowly northward over about 5°, becoming distorted in form and gradually fainter. The trail is indicated on the chart by a feathered arrow. W. C. BRENKE.

UNIVERSITY OF ILLINOIS OBSERVATORY, 1902, Jan. 5.

Observations of Meteors Nov. 13-16, 1901.—As in previous years, I observed with Mr. Charles A. Post from his Observatory at Bayport, Long Island. We arranged (1) to photograph meteor trails with four cameras mounted on the equatorial which was driven by an excellent clock, (2) to count the meteors and (3) to record individual meteors which exhibited striking peculiarities.

(1). The equatorial and cameras employed are shown in Plate II, POPULAR ASTRONOMY (No. 82), February 1901.

The mounting of the cameras was changed somewhat from the method used in November, 1900. The Darlot portrait lens was taken from the extreme end of the declination axis, and placed on the telescope near the eye end; the Voigtlander portrait lens was taken off the declination axis, and not used; the Anthony portrait lens was mounted near the object glass of the telescope; the Willard lens was left on the declination axis and the Goerz lens (loaned us again this year by Mr. L. J. R. Holst, of New York City) was mounted on a fork fastened to the end of the polar axis.

The apertures and focal lengths are given in the following table:

Instrument.	Aperture.	Focal Length.
Equatorial telescope	6 inches	90 inches
Willard photographic doublet	5½	23
Darlot portrait	1½	6½
Anthony portrait	3	13½
Goerz wide angle double anastigmatic	1½	9½

(1). PHOTOGRAPHIC EXPOSURES.

Nov. 13. 12:00 to 18:00 (Standard time on 75° meridian). A number of experimental plates were taken, but no effort was made to photograph meteors, as so few were seen.

Nov. 14. 11:20 to 12:24. Exposed the Goerz lens on the belt of Orion.

13:15 to 14:05. Exposed all the cameras, pointed as follows: Willard and Anthony lenses at Procyon; Goerz lens at belt of Orion; and Darlot lens at μ and ϵ Leonis.

At 15:00 the sky clouded but cleared again at 15:30.

15:42 to 16:30 all cameras were exposed. The Willard and Anthony on ϵ Leonis; the Goerz on ζ, ϵ, δ Hydræ and the Darlot on Ursa Major.

The clouds began to spread over the sky again, and in a short time it was impossible to see a star. The Observatory was closed unfortunately, and when the observers came out of the house, after partaking of the late supper prepared for them, they found the sky clear and the meteors falling quite fast. They then confined their attention to counting and observing the meteors.

Nov. 15. 11:45 to 13:00. Exposed all cameras. Willard and Anthony lenses on Pollux; Goerz lens on Procyon, and Darlot lens on γ Geminorum.

14:35 to 15:45. Exposed all cameras. Willard and Anthony on ζ Leonis; Goerz on Regulus and Darlot on λ and μ Leonis Minoris. Clock did not work as well as usual.

16:01 to 17:00. Willard lens was omitted. The other cameras were pointed as in the preceding exposure.

Mr. Post developed all the plates. The plates taken on Nov. 14 show a number of trails. Quite a remarkable meteor trail is shown on the plates taken with the Willard and the Anthony lenses between 15:42 and 16:30. The notes given under "Record of individual meteors" seem to show that this meteor appeared at 15:58.

(2). COUNT OF METEORS.

Only during the night of Nov. 14 was any careful attempt made to count. Miss Edith Post and Miss Greenough observed the eastern sky looking toward the radiant. At first both observed the same part of the sky but after 38 had been counted Miss Greenough observed the south eastern sky, from the line from the radiant to the zenith, and Miss Post observed the north-eastern sky from the same line. The count was as follows:

Nov. 14. 12:15 to 13:40. Miss Post and Miss Greenough, 38; Miss Post, northeastern sky, 31; Miss Greenough, southeastern sky, 31.

13:40 to 14:20. Messrs. Post and Rees looking out of the opening in the roof of the Observatory toward the radiant counted 20.

14:20 to 15:00. Miss Post, northeastern sky, 10; Miss Greenough, southeastern sky, 15.

15:50 to 17:55. The Misses Post and Greenough counted, being assisted from 16:30 to 17:55 by Post and Rees. The total count of the four observers was 273. Total for the evening 418.

Nov. 15. Post and Rees assisted by Mr. Post's "handy man" counted, while engaged on the photographic work and looking out of the Observatory opening, as follows:

11:45 to 13:00. 25, several of which were non Leonids.

14:35 to 15:45. 3, of which 1 was a non Leonid.

16:01 to 17:00. 23, several non Leonids.

Nov. 16. 12:00 to 17:00. Looked out frequently but saw so few that no record was kept.

(3). Individual Meteors.

Nov. 14. 11:30. Two bright Leonids, trails yellow-red 10° long, width of trail *very distinct.*
11:51. Leonid from Procyon to θ Orionis, blue streak.
12:07 From star above Procyon to "yardstick," trail 25° long, lasted several seconds, yellow, Leonid.
12:10. Leonid through Ursa Major, bright trail.
12:15. " " " "
12:17. " " Auriga.
13:18. Brilliant Leonid, near radiant, very small trail, orange color, bright as Mars at best.
13:27. Fine Leonid from Leo to zenith, trail 30° long, yellow-red.
13:30. Leonid through Ursa Major, fine.
13:40. Meteor near Procyon, from zenith down, short trail.
13:44. Fine Leonid through bowl of dipper, trail 5°.
13:51. Leonid under Procyon, 8° trail, yellow red.
15:58. Brilliant Leonid, trail 5°, lasted twenty seconds, blue-white, first magnitude.
16:04. Leonid under Procyon, blue-white, 10° trail.
17:28. Two brilliant meteors visible at same time, trails crossed, bright heads. One came from radiant and passed near α and β Canum Venaticorum, trail 30° long and lasted several seconds. The second seemed to come from below β Leonis and cut the trail of the first under Canes Venatici, trail 30°. Magnitude of each, 2.

Nov. 15. 14:52. Bright Leonid under Leo Minor.
15:37. Leonid bright as Jupiter, in sickle, blue and red trail.
About 15:55. Fire ball below Leo came from Orion.
16:10. From zenith through Leo Minor (λ and μ), long train 40°.
About 17:00 the zodiacal light showed itself in a grandly beautiful manner.

Columbia University Observatory. J. K. Rees.

Elementary Experiments in Observational Observatory.—Professor G. W. Myers, who is now in charge of mathematics and astronomy in the Chicago Institute, an academic and pedagogic institution, is also connected with "School Science," and has given in that publication much that is helpful to teachers in the way of simple illustrations of important facts in astronomy by way of observation, and the easy apparatus of home make that any one may use for carrying forward experiments of observation desired.

In a neat pamphlet of 48 pages, Professor Myers presents 44 of these experiments with cuts illustrating the same. The descriptive matter accompanying each is well chosen. This is another step in the direction of laboratory teaching in the elements of astronomy so much needed even in all grades of instruction in astronomy. Correspond with Professor G. W. Myers about his elementary experiments in observational astronomy. The address is 6026 Monroe Ave., Chicago, Ill.

Large space in our notes is taken up this month with accounts of the Leonid meteors. We have still in hand other important communications relating to the Leonids which will be published later.

Mr. Geo. Gildersleve for 10 years chairman of the Astronomical Section of the Maryland Academy of Sciences, died Dec. 31st, 1900.

In March, 1901, his widow presented to the Academy, his 6 1-10-inch refractor, made for him in 1884 by Professor C. S. Hastings, then of the Johns Hopkins University, now of Yale. She also donated his sidereal clock, astronomical library, observing records, and a sunspot diary kept for 25 years.

The Academy has recently sold its former home and purchased a more desirable building, and greatly improved the same, including a roomy Observatory with revolving dome, using for a pier a very solid central chimney not otherwise needed.

Mr. Sullivan Pitts, an active member, also presented to the Section a 6½-inch reflector by Brashear.

This has been mounted equatorially and upon a heavy truck, arranged to be run out upon a very solid, strongly built platform 8 × 12 feet adjoining the Observatory, and it can be very conveniently used.

The two instruments will be actively employed in general work by the members.

Mrs. Gildersleve died Dec. 10, 1901, leaving to the Academy $1,000 in her will.

Astronomical and Astrophysical Society.—At the annual meeting of the Astronomical and Astrophysical Society of America held in Washington during the holiday season five public sessions at the Cosmos Club were given to the reading and discussion of scientific papers. There were about forty of these papers and abstracts of them together with a general account of the proceedings will be published in *Science* by the editor of the Society, Professor W. S. Eichelberger.

The social features of the meeting comprised a conversazione at the Arlington Hotel, with exhibition of lantern slides, transparencies, and apparatus and also a luncheon and dinner at one of the Washington restaurants. On New Year's Day the members of the Society in a body paid their respects to the President of the United States.

About thirty new members were elected to the Society which now includes within its membership nearly every working astronomer in the United States. The following officers were elected to serve during the ensuing year: President, Simon Newcomb; First Vice President, George E. Hale; Second Vice President, W. W. Campbell; Treasurer, C. L. Doolittle; Councilor, E. C. Pickering; Councilor, R. S. Woodward. To these should be added the following officers who hold over from the previous year: Secretary, George C. Comstock; Councilor, Ormond Stone; Councilor, S. J. Brown.

Taken as a whole this meeting, the first winter session of the Society, was so well attended and so successful that the Council decided to repeat the experiment of a winter meeting in 1902-'03 and the next session of the Society will therefore be held in Washington during convocation week, *i. e.* between the next Christmas and New Year's day.

We have just received an article on the North polar rifts and Arctic canals on Mars by Percival Lowell. This article is accompanied with drawings made by Mr. Lowell and Mr. A. E. Douglas which represent the appearance of the surface of that planet at its last opposition.

We are delighted to know that Mr. Lowell is again able to give some attention to astronomical work wherein he has wrought with great success in recent years.

Civil Service Examination for Assistant Astronomer at the U. S. Naval Observatory Dec. 11-13, 1901, was as follows:

1. Pure mathematics, practical and spherical astronomy, celestial mechanics, general mechanics, optics, and French and German	20
2. Experience (*a*) in making astronomical observations, (*b*) in making astronomical computations, (*c*) in making and repairing, mounting and dismounting, and in caring for astronomical instruments, including auxiliary apparatus	40
3. Ability to carry on original astronomical investigations as evidenced by printed memoirs or otherwise	40
Total	100

The examination on the technical subjects under "I" was to be entirely of a scholastic character and to occupy three days. Under the second and third subjects applicants were expected to submit evidence of their experience and ability. This evidence should be full and complete. The statements of the applicants on application form 375 were also considered in connection with the rating of the second and third subjects. Age limit 20 to 45 years.

This examination was open to all citizens of the United States who complied with the requirements and who desired to enter the service. In the circular announcing this examination, Nov. 19, 1901, it was stated, however, that it would be useless for anyone to apply who had not had considerable training and experience along the lines referred to in the subjects of the examination. All persons who considered themselves qualified were invited to apply, and such persons were to be examined and graded with entire impartiality and wholly without regard to any consideration save their ability as demonstrated by their examinations.

Limits of Vision.—My attention has been called to the article, "The Limits of Vision, by Edwin Holmes, in Number 89 of POPULAR ASTRONOMY. The article is taken from *The Journal of the British Astronomical Association*, Vol. XI, No. 9, July 26, '01.

In Number 87, p. 414, are given the opinions of several gentlemen who heard Mr. Holmes' paper read; when they particularly referred to his statements on the visibility of Jupiter's satellites.

In *The Observatory* for September, 1901, General J. F. Tennant expresses his opinion thereon.

I would not call attention to Mr. Holmes' dicta except that some young astronomers may possibly think he is taken as authority in such a matter. So I merely ask a reference to pages 66 and 67 upon the Visibility of Jupiter's Satellites in my paper "The apparent projection of stars upon the bright limb of the Moon at occultation, and similar phenomena at total eclipses," "Transits of Venus and Mercury," etc., etc., which was published in the *Proceedings of the California Academy of Sciences*, Third Series, Math.-Phys., Vol. I., No. 7, and also in pamphlet form.

The professor referred to on page 67 as seeing *three* satellites of Jupiter at one and the same time, is J. R. Eastman, lately professor at the U. S. Naval Observatory, now retired by age limit. Astronomers must know him personally.

I could have named one of my old professors, but have preferred to name the living to verify the remarkable statement which is made on page sixty-seven.

GEORGE DAVIDSON.

BOOK NOTICE.

Other Worlds, is the title of a new book by Garrett P. Serviss, who is also author of "Astronomy with an Opera Glass" and "Pleasures of the Telescope."

The aim of the author is to bring together the leading facts known to astronomy, including those of late discoveries and so relate them that any intelligent reader may gain a comprehensive view of the science, and also learn somewhat in detail the sources of interest that occupy the minds of scholars as they toil on to broaden the range of knowledge especially related to the habitability of other worlds than ours. There is now, and always has been, a remarkable popular interest in the question whether or not other worlds are really habitable, and if so, are they peopled with beings like ourselves. It has been said, how truly we do not know, that one of the moving ideas in the mind of Mr. James Lick, the founder of the great Lick Observatory, on Mount Hamilton, California, was to provide a telescope large enough to determine whether or not the Moon was inhabited. In the mind of a man not especially skilled in astronomy, such a motive would not be an unworthy one, especially if it should lead him to do great service for science, as that noble Observatory is now doing, and doubtless will do in long time to come.

In popular way the author makes very readable sketches of Mercury, the world of two faces and many continents, of Venus the twin of the Earth, Mars a world more advanced than ours, of the asteroids, a family of dwarf worlds, of Jupiter, the greatest of the known worlds, of Saturn, the planet rings and of the Moon, the child of the Earth and Sun.

Mr. Serviss has done good work in writing down to a popular plane many things that unskilled people want to know and can well comprehend if stated in language that has any meaning for ordinary intelligent readers.

The Appletons are publishers and the reading public knows their work is always the best.

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